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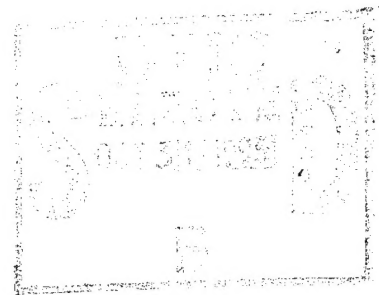## University of Cincinnati

Proof of Crossplane Symmetry for a Conical Navier-Stokes Solver

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Abstract

A formal proof is given for the symmetry of a conical Navier-Stokes equation solver that has been employed in the computation of vortex asymmetries. The conical Navier-Stokes equations are presented as developed from the generalized coordinate three-dimensional Navier-Stokes equation approach. The solver is then discussed in detail. The proof is first sketched to clarify what must be shown to demonstrate symmetry. The details of the implicit and explicit side symmetry relations are then presented using in part the MACSYMA symbolic manipulation expert system.

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Introduction

This report was prompted by the need to demonstrate symmetry for a conical Navier-Stokes algorithm used in studies of vortex asymmetry about cones at incidence. This issue arises because vortex asymmetry has been observed to occur "naturally" for the conical Navier-Stokes equations (i.e., without external perturbations) whereas it is apparently not observed in similar three-dimensional Navier-Stokes calculations. Vortex asymmetry is found in two of three possible solutions to the nonlinear equation set. These solutions have been found to be stable to perturbations whereas the third (symmetric) solution is thought to be unstable. In fact, the asymmetric solution is found after the solver has converged partially to the symmetric solution. It is felt that roundoff error perturbations excite the instability and redirect the solver to the asymmetric solution. However, it is also conceivable that some algorithm related asymmetries exist which produce the same result, thereby negating any conclusions drawn from solutions obtained by these solvers. It is therefore imperative that the algorithm be symmetric before computational arithmetic is employed.

The following sections report the governing equations that form the basis of this solver, the numerical method used and finally the symmetry proof.

Governing Equations

The conical thin-layer Navier-Stokes equations are obtained from discretizations of the generalized coordinate three-dimensional thin-layer Navier-Stokes equations. A grid is chosen such that the ξ-direction is along rays from the cone tip. Properties are then assumed constant along these rays. In their most general sense the thin-layer Navier-Stokes equations may be written

$$\frac{\partial Q}{\partial \tau} + \frac{\partial F_i}{\partial \xi} + \frac{\partial (G_i - S_v)}{\partial \eta} + \frac{\partial H_i}{\partial \zeta} = 0 \qquad (1)$$

where

$$Q = \begin{bmatrix} \rho \\ \rho u \\ \rho v \\ \rho w \\ e \end{bmatrix} \quad F_i = \frac{1}{J}\begin{bmatrix} \rho U \\ \rho u U + \xi_x p \\ \rho v U + \xi_y p \\ \rho w U + \xi_z p \\ (e+p)U \end{bmatrix} \quad G_i = \frac{1}{J}\begin{bmatrix} \rho V \\ \rho u V + \eta_x p \\ \rho v V + \eta_y p \\ \rho w V + \eta_z p \\ (e+p)V \end{bmatrix}$$

$$H_i = \frac{1}{J}\begin{bmatrix} \rho W \\ \rho u W + \zeta_x p \\ \rho v W + \zeta_y p \\ \rho w W + \zeta_z p \\ (e+p)W \end{bmatrix} \quad S_v = \frac{M_\infty \mu}{Re_L J}\begin{bmatrix} 0 \\ \eta_x \sigma_x + \eta_y \tau_{xy} + \eta_z \tau_{xz} \\ \eta_x \tau_{xy} + \eta_y \sigma_y + \eta_z \tau_{yz} \\ \eta_x \tau_{xz} + \eta_y \tau_{yz} + \eta_z \sigma_z \\ \bar{u}S_{v_2} + \bar{v}S_{v_3} + \bar{w}S_{v_4} - \eta_x q_x - \eta_y q_y - \eta_z q_z \end{bmatrix}$$

$$U = \xi_x u + \xi_y v + \xi_z w$$
$$V = \eta_x u + \eta_y v + \eta_z w$$
$$W = \zeta_x u + \zeta_y v + \zeta_z w$$

with $\bar{u}, \bar{v}$ & $\bar{w}$ as average velocities between cells and $\sigma_x, \sigma_y, \sigma_z, \tau_{xy}, \tau_{xz}$ & τ_{yz} having their usual definitions.

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A steady form of the above equations is found by neglecting the time derivative of the conserved variables. The resulting equations are solved on a single crossflow (η,ζ) plane grid in which the ξ-direction lines are rays from the cone tip or origin. The conical equations result when constant property boundary conditions are enforced in the radial direction, as described later in the numerical method section. It should be noted that these boundary conditions are necessary only because a three-dimensional solver has been modified to form the conical solver. Boundary conditions are needed only on the surface and far field boundaries for the conical Navier-Stokes equations.

Numerical Method

An implicit upwind symmetric factorization finite volume scheme was employed to solve the above equations. The basic algorithm consists of the implicit or left hand side (LHS) and the explicit or right hand side (RHS) in the form

$$LHS(Q^n)\,\Delta^n Q = RHS(Q^n) \tag{2}$$

An iteration proceeds from a known Q^n to Q^{n+1} by solving equation (2) for $\Delta^n Q$ and using

$$Q^{n+1} = Q^n + \Delta^n Q$$

RHS

The RHS is differenced using Roe's [Roe] flux difference splitting (FDS) and the Van Albada [VanAl] limiter through Van Leer's [VanLe] MUSCL approach. A convenient way of writing the FDS is presented by Vatsa, Thomas and Wedan [VTW], who detail the contribution of the ξ-direction fluxes as

$$\frac{\partial F}{\partial \xi} = \frac{F_{i+1/2} - F_{i-1/2}}{\Delta \xi}$$

where

$$F_{i+1/2} = \frac{1}{2}\Big[F(Q_L) + F(Q_R) - |\tilde{A}|(Q_R - Q_L)\Big]_{i+1/2}$$

and Q_L and Q_R are functions of neighboring points as described later in the limiter section and $|\tilde{A}|$ is the diagonalized matrix

$$|\tilde{A}| = T|\Lambda|\,T^{-1}$$

formed from the Roe averaged variables (a function of Q_L and Q_R) with Λ the diagonal eigenvalue matrix, T the matrix of left eigenvectors of A and T^{-1} the matrix of right eigenvectors of A. Note that these matrices are also used for the LHS but in

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a slightly different form. The actual matrices can be found in several places including the Vatsa, Thomas and Wedan reference or through the MACSYMA outputs to be presented in a later section.

Flux Limiters

Of interest at this point is how Q_L and Q_R are chosen. In this work Van Leer's [VanLe] MUSCL approach is utilized with the Van Albada [VanAl] flux limiter. The MUSCL approach can be utilized with many limiters, as such, it can be written as

$$Q_L = Q_i + \frac{1}{4}\left\{(1 - \kappa)\hat{\Delta}_{i-1/2} + (1 + \kappa)\tilde{\Delta}_{i+1/2}\right\}$$

$$Q_R = Q_{i+1} - \frac{1}{4}\left\{(1 + \kappa)\hat{\Delta}_{i+1/2} + (1 - \kappa)\tilde{\Delta}_{i+3/2}\right\}$$

The Van Albada limiter is obtained by setting $\kappa = 1$

$$Q_L = Q_i + \frac{1}{2}\tilde{\Delta}_{i+1/2}$$

$$Q_R = Q_{i+1} - \frac{1}{2}\hat{\Delta}_{i+1/2} = Q_{i+1} - \frac{1}{2}\tilde{\Delta}_{i+3/2}$$

and

$$\tilde{\Delta}_{i+1/2} = \frac{\Delta_{i-1/2}\left[\Delta^2_{i+1/2} + \epsilon\right] + \Delta_{i+1/2}\left[\Delta^2_{i-1/2} + \epsilon\right]}{\Delta^2_{i+1/2} + \Delta^2_{i-1/2} + 2\epsilon}$$

where

$$\Delta_{i+1/2} = Q_{i+1} - Q_i$$

The value of ϵ is typically taken to be a small number to avoid spurious zero divisions.

The above describes how the inviscid terms of the RHS are calculated. The viscous terms are included through central differencing of S_v. This completely describes the algorithm solved via the implicit system. Details of the algorithm can be obtained through the references or by examining the input to MACSYMA for the symmetry checks.

LHS

The LHS can be described by discretizing equation (1) using a simple implicit scheme

$$\frac{\Delta^n Q}{\Delta \tau} + \frac{\partial F_i^{n+1}}{\partial \xi} + \frac{\partial (G_i^{n+1} - S_v^{n+1})}{\partial \eta} + \frac{\partial H_i^{n+1}}{\partial \zeta} = 0 \tag{3}$$

Subtracting the n-level steady terms from both sides and dropping the viscous terms from the LHS gives

$$\frac{\Delta^n Q}{\Delta \tau} + \frac{\partial (F_i^{n+1} - F_i^n)}{\partial \xi} + \frac{\partial (G_i^{n+1} - G_i^n)}{\partial \eta} + \frac{\partial (H_i^{n+1} - H_i^n)}{\partial \zeta} \tag{4}$$

$$= -\left[\frac{\partial F_i^n}{\partial \xi} + \frac{\partial (G_i^n - S_v^n)}{\partial \eta} + \frac{\partial H_i^n}{\partial \zeta} \right] = -RHS^n$$

and linearizing the inviscid fluxes about the nth level

$$F_i^{n+1} \approx F_i^n + \left. \frac{\partial F_i}{\partial Q} \right|_n \Delta Q^n = F_i^n + A^n \Delta^n Q \tag{5}$$

$$G_i^{n+1} \approx G_i^n + \left. \frac{\partial G_i}{\partial Q} \right|_n \Delta Q^n = G_i^n + B^n \Delta^n Q \tag{6}$$

$$H_i^{n+1} \approx H_i^n + \left. \frac{\partial H_i}{\partial Q} \right|_n \Delta Q^n = H_i^n + C^n \Delta^n Q \tag{7}$$

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The above describes how the inviscid terms of the RHS are calculated. The viscous terms are included through central differencing of S_v. This completely describes the algorithm solved via the implicit system. Details of the algorithm can be obtained through the references or by examining the input to MACSYMA for the symmetry checks.

LHS

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Subtracting the n-level steady terms from both sides and dropping the viscous terms, S_v^{n+1} and S_v^n, from the LHS gives

$$\frac{\Delta^n Q}{\Delta \tau} + \frac{\partial (F_i^{n+1} - F_i^n)}{\partial \xi} + \frac{\partial (G_i^{n+1} - G_i^n)}{\partial \eta} + \frac{\partial (H_i^{n+1} - H_i^n)}{\partial \zeta} \tag{4}$$
$$= -\left[\frac{\partial F_i^n}{\partial \xi} + \frac{\partial (G_i^n - S_v^n)}{\partial \eta} + \frac{\partial H_i^n}{\partial \zeta} \right] = -RHS^n$$

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$$G_i^{n+1} \approx G_i^n + \left. \frac{\partial G_i}{\partial Q} \right|_n \Delta Q^n = G_i^n + B^n \Delta^n Q \tag{6}$$

$$H_i^{n+1} \approx H_i^n + \left. \frac{\partial H_i}{\partial Q} \right|_n \Delta Q^n = H_i^n + C^n \Delta^n Q \tag{7}$$

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results in

$$\frac{\Delta^n Q}{\Delta \tau} + \frac{\partial}{\partial \xi}(A^n \Delta^n Q) + \frac{\partial}{\partial \eta}(B^n \Delta^n Q) + \frac{\partial}{\partial \zeta}(C^n \Delta^n Q) = -RHS^n$$

or, in operator notation

$$\left[\frac{I}{\Delta \tau} + \left(\frac{\partial A}{\partial \xi}\right)^n + \left(\frac{\partial B}{\partial \eta}\right)^n + \left(\frac{\partial C}{\partial \zeta}\right)^n\right]\Delta^n Q = -RHS^n \qquad (8)$$

Finally, multiplying by $\Delta \tau$ gives

$$\left[I + \Delta \tau \left\{\left(\frac{\partial A}{\partial \xi}\right)^n + \left(\frac{\partial B}{\partial \eta}\right)^n + \left(\frac{\partial C}{\partial \zeta}\right)^n\right\}\right]\Delta^n Q = -\Delta \tau RHS^n \qquad (9)$$

where RHS^n is obtained as described above. It is important to note that the scheme is now "semi" implicit since the viscous terms are lagged. However, this does not affect the solution at convergence since it is defined as a zero RHS to machine accuracy. Next the LHS is differenced using the Steger-Warming flux vector splitting (FVS). The scheme can be written

$$\left(I + \Delta \tau \left\{\nabla_\xi A^+ + \Delta_\xi A^- + \nabla_\eta B^+ + \Delta_\eta B^- + \nabla_\zeta C^+ + \Delta_\zeta C^-\right\}\right)\Delta^n Q$$
$$= -\Delta \tau RHS^n \qquad (10)$$

Where $A^\pm, B^\pm, C^\pm$ are the generalized coordinate Steger-Warming [StegWar] FVS Jacobians; $\Delta \xi, \Delta \eta, \Delta \zeta$ are assumed to be unity; and Δ_ξ and ∇_ξ, etc., are the standard two point forward and backward difference operators

$$\Delta_\xi(\ ) = (\ )_{i+1jk} - (\ )_{ijk}$$
$$\nabla_\xi(\ ) = (\ )_{ij,k} - (\ )_{i-1jk}$$

It should be noted that the bracketed terms are acting as operators on $\Delta^n Q$ (i.e., $\Delta_\xi A^- \Delta^n Q = [A^- \Delta^n Q]_{i+1jk} - [A^- \Delta^n Q]_{ijk}$). Details of the Jacobian matrices can be found in the references or can be inferred from the proof. The above produces a block

septa-diagonal system which is not easy to solve. However, the system can be approximately factored so that two block tetra-diagonal systems result

$$\left(I + \Delta\tau\left\{\nabla_\xi A^+ + \nabla_\eta B^+ + \Delta_\eta B^-\right\}\right) \quad\quad (11)$$
$$\left(I + \Delta\tau\left\{\Delta_\xi A^- + \nabla_\zeta C^+ + \Delta_\zeta C^-\right\}\right)\Delta^n Q = -\Delta\tau RHS^n$$

This system can then be solved in two steps

$$\left(I + \Delta\tau\left\{\nabla_\xi A^+ + \nabla_\eta B^+ + \Delta_\eta B^-\right\}\right)Q^* = -\Delta\tau\,RHS^n \quad (12a)$$
$$\left(I + \Delta\tau\left\{\Delta_\xi A^- + \nabla_\zeta C^+ + \Delta_\zeta C^-\right\}\right)\Delta^n Q = Q^* \quad\quad (12b)$$

by employing a block tri-diagonal solver while sweeping the ξ-direction in (η,ζ)-planes. For three dimensional problems, forward sweeps are used for equation (12a) and backward sweeps for equation (12b). It is important to note that the above system is symmetric in ζ since both C^+ and C^- are in the same factor. This will become more apparent in the symmetry proof.

The conical solver uses equation (12) in a somewhat abbreviated form. That is, only one plane of cells is considered, therefore,

$$\Delta_\xi A^- \approx -A^-_{i,j,k}$$
$$\nabla_\xi A^- \approx A^-_{i,jk}$$

This approximation essentially assumes that $\Delta^n Q=0$ for the off plane terms (although they are computed through the conical flow boundary condition.) This term can be removed to improve algorithm efficiency, but has no detrimental effect on the solution. It was retained in the current solver. In any event, it has no bearing on algorithm symmetry as will be shown in the proof.

The conical LHS is as described above and is always solved on a conical grid.

Symmetry Proof

The MACSYMA symbolic manipulation expert system was used to determine the symmetry of the above algorithm. The proof is first sketched in a general sense to provide an overview and then the details are presented.

General Proof

As presented earlier, the conical solver was developed from a generalized coordinate three dimensional solver by simplifying the algorithm when applied on a conical grid. If Cartesian coordinates are used to describe the physical space, the x-direction corresponds to the cone axis; the y-direction is vertical, such that incidence is achieved by a pitch up in the (x,y) plane; and the z-direction is orthogonal to the (x,y) plane. In the computational space the ξ-direction lines are rays from the cone tip and the (η, ζ) plane is perpendicular to the cone axis, with the η-direction normal to the axis and the ζ-direction azimuthal.

For this geometry and grid, symmetry in the crossplane requires that the mirror image grid points (i,j,k) and $(\hat{i},\hat{j},\hat{k})$ at locations (x,y,z) and (x,y,-z), respectively, must have

$$Q_{ijk} = MQ_{\hat{i}\hat{j}\hat{k}}$$

where

$$Q = \begin{bmatrix} \rho \\ \rho u \\ \rho v \\ \rho w \\ e \end{bmatrix} \qquad and \qquad M = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Clearly, $M = M^{-1}$.

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Furthermore, the metrics are related in the following manner

$$\left(\frac{\xi_x}{J}\right)_{i,j,k} = \left(\frac{\xi_x}{J}\right)_{\hat{i},\hat{j},\hat{k}}$$

$$\left(\frac{\xi_y}{J}\right)_{i,j,k} = \left(\frac{\xi_y}{J}\right)_{\hat{i},\hat{j},\hat{k}} = 0$$

$$\left(\frac{\xi_z}{J}\right)_{i,j,k} = \left(\frac{\xi_z}{J}\right)_{\hat{i}\hat{j}\hat{k}} = 0$$

$$\left(\frac{\eta_x}{J}\right)_{i,j,k} = \left(\frac{\eta_x}{J}\right)_{\hat{i},\hat{j},k}$$

$$\left(\frac{\eta_y}{J}\right)_{i,j,k} = \left(\frac{\eta_y}{J}\right)_{\hat{i},\hat{j},k}$$

$$\left(\frac{\eta_z}{J}\right)_{i,j,k} = -\left(\frac{\eta_z}{J}\right)_{\hat{i}\hat{j}k}$$

$$\left(\frac{\zeta_x}{J}\right)_{i,j,k} = -\left(\frac{\zeta_x}{J}\right)_{\hat{i}\hat{j}k}$$

$$\left(\frac{\zeta_y}{J}\right)_{i,j,k} = -\left(\frac{\zeta_y}{J}\right)_{\hat{i}\hat{j}k}$$

$$\left(\frac{\zeta_z}{J}\right)_{i,j,k} = \left(\frac{\zeta_z}{J}\right)_{\hat{i}\hat{j},k}$$

Hence, the cell contravariant velocities

$$U = \xi_x u + \xi_y v + \xi_z w$$
$$V = \eta_x u + \eta_y v + \eta_z w$$
$$W = \zeta_x u + \zeta_y v + \zeta_z w$$

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are related as per

$$U_{i,j,k} = U_{i,\hat{j},\hat{k}}, \quad V_{i,j,k} = V_{i,\hat{j},\hat{k}}, \quad W_{i,j,k} = -W_{i,\hat{j},\hat{k}}$$

To prove symmetry we start with the assumption that the solution from the previous iteration (n-1) is symmetric (for n=1, this implies the initial condition is symmetric), hence

$$RHS^n_{i,j,k} = M\,RHS^n_{i,\hat{j},\hat{k}} \qquad (13)$$

Consequently, we expect the intermediate "solution" obtained by solving equation (12a) to be symmetric

$$Q^*_{i,j,k} = M\,Q^*_{i,\hat{j},\hat{k}} \qquad (14)$$

and hence, the final solution is also symmetric because the change obtained by solving equation (12b) is symmetric

$$\Delta^n Q_{i,j,k} = M\,\Delta^n Q_{i,\hat{j},\hat{k}} \qquad (15)$$

RHS

Referring to equation (1) it is easy to show that a simple central difference of the RHS is symmetric since

$$F_{i,j,k} = M F_{i,\hat{j},\hat{k}}$$
$$G_{i,j,k} = M G_{i,\hat{j},\hat{k}}$$
$$H_{i,j,k} = -M H_{i,\hat{j},\hat{k}}$$

and because the azimuthal ordering prescribes the correspondence $(i,j,k+1)$ to $(\hat{i},\hat{j},\hat{k}-1)$ and $(i,j,k-1)$ to $(\hat{i},\hat{j},\hat{k}+1)$

$$H_{i,j,k\pm1} = -M H_{\hat{i}\hat{j}\hat{k}\mp 1}$$

therefore,

$$\left(\frac{\partial F}{\partial \xi}\right)_{ijk} = M\left(\frac{\partial F}{\partial \xi}\right)_{\hat{i}\hat{j}\hat{k}}$$

$$\left(\frac{\partial G}{\partial \eta}\right)_{ijk} = M\left(\frac{\partial G}{\partial \eta}\right)_{\hat{i}\hat{j}\hat{k}}$$

$$\left(\frac{\partial H}{\partial \zeta}\right)_{ijk} = M\left(\frac{\partial H}{\partial \zeta}\right)_{\hat{i}\hat{j}\hat{k}}$$

This relationship can also be demonstrated for the flux limited Roe FDS discretization, but it is not visually apparent from the equations. It should be noted that the azimuthal ordering oddity significantly complicates the MACSYMA comparison because it requires the identification of the corresponding terms a priori, since the performance of MACSYMA is related to the complexity of the expressions. The MACSYMA derived proof for the RHS requires two steps; demonstrate symmetry for the flux limited variables and then symmetry for the remaining terms. A separate proof is given for each direction as this reduces the MACSYMA workload to a manageable size. These proofs are found in the RHS Proof section following the general proof.

LHS

The LHS expressions also contain the ζ-direction oddity, however, symmetry is easily demonstrated because the following relationships can be proved

$$A^{\pm}_{ijk}M = MA^{\pm}_{\hat{i}\hat{j}\hat{k}} \qquad (16)$$

$$B^{\pm}_{ijk}M = MB^{\pm}_{\hat{i}\hat{j}\hat{k}} \qquad (17)$$

$$C^{\pm}_{ijk}M = -MC^{\mp}_{\hat{i}\hat{j}\hat{k}} \qquad (18)$$

In addition, we have

$$C^{\pm}_{ijk\pm1}M = -MC^{\mp}_{\hat{i}\hat{j}\hat{k}\mp1} \qquad (19)$$

due to the azimuthal direction ordering reversal. These relations will be proven in the LHS Proof section. It should be clear that symmetry cannot be guaranteed in the algorithm unless C^{+} and C^{-} appear in the same factor.

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Given the above relationships consider equation (12a) at point (i,j,k) with the operators expanded

$$Q^*_{ijk} + \Delta\tau\Big([A^+Q^*]_{ijk} - [A^+Q^*]_{i-1jk} + [B^+Q^*]_{ijk} - [B^+Q^*]_{ij-1k}$$
$$+ [B^-Q^*]_{ij+1k} - [B^-Q^*]_{ijk}\Big) = RHS^n_{ijk} \qquad (20)$$

and at the point $(\hat{i},\hat{j},\hat{k})$

$$Q^*_{\hat{i}\hat{j}\hat{k}} + \Delta\tau\Big([A^+Q^*]_{\hat{i}\hat{j},\hat{k}} - [A^+Q^*]_{\hat{i}-1\hat{j},\hat{k}} + [B^+Q^*]_{\hat{i}\hat{j}\hat{k}} - [B^+Q^*]_{\hat{i}\hat{j}-1\hat{k}}$$
$$+ [B^-Q^*]_{\hat{i}\hat{j}+1\hat{k}} - [B^-Q^*]_{\hat{i}\hat{j},\hat{k}}\Big) = RHS^n_{\hat{i}\hat{j}\hat{k}} \qquad (21)$$

Pre-multiply equation (21) by M and use equation (13) to obtain

$$MQ^*_{\hat{i}\hat{j}\hat{k}} + \Delta\tau\Big([MA^+Q^*]_{\hat{i}\hat{j},\hat{k}} - [MA^+Q^*]_{\hat{i}-1\hat{j},\hat{k}} + [MB^+Q^*]_{\hat{i}\hat{j},\hat{k}} - [MB^+Q^*]_{\hat{i}\hat{j}-1,\hat{k}}$$
$$+ [MB^-Q^*]_{\hat{i}\hat{j}+1\hat{k}} - [MB^-Q^*]_{\hat{i}\hat{j}\hat{k}}\Big) = RHS^n_{ijk} \qquad (22)$$

Using relations (16)-(18) in equation (22) gives

$$MQ^*_{\hat{i}\hat{j}\hat{k}} + \Delta\tau\Big(A^+_{ijk}MQ^*_{\hat{i}\hat{j}\hat{k}} - A^+_{i-1jk}MQ^*_{\hat{i}-1\hat{j}\hat{k}} + B^+_{ijk}MQ^*_{\hat{i}\hat{j}\hat{k}} \qquad (23)$$
$$- B^+_{ij-1k}MQ^*_{\hat{i}\hat{j}-1\hat{k}} + B^-_{ij+1k}MQ^*_{\hat{i}\hat{j}+1,\hat{k}} - B^-_{ijk}MQ^*_{\hat{i}\hat{j},\hat{k}}\Big) = RHS^n_{ijk}$$

Subtracting equation (23) from (20) yields

$$[Q^*_{ijk} - MQ^*_{\hat{i}\hat{j}\hat{k}}] + \Delta\tau\Big(A^+_{ijk}[Q^*_{ijk} - MQ^*_{\hat{i}\hat{j}\hat{k}}] - A^+_{i-1jk}[Q^*_{i-1jk} - MQ^*_{\hat{i}-1\hat{j}\hat{k}}]$$
$$+ B^+_{ijk}[Q^*_{ijk} - MQ^*_{\hat{i}\hat{j}\hat{k}}] - B^+_{ij-1k}[Q^*_{ij-1k} - MQ^*_{\hat{i}\hat{j}-1,\hat{k}}]$$
$$+ B^-_{ij+1k}[Q^*_{ij+1k} - MQ^*_{\hat{i}\hat{j}+1\hat{k}}] - B^-_{ijk}[Q^*_{ijk} - MQ^*_{\hat{i}\hat{j},\hat{k}}]\Big) = 0$$

The first, second, fourth and seventh terms within brackets imply equation (14)

$$Q^*_{i,j,k} = MQ^*_{\hat{i}\hat{j}\hat{k}}$$

Similarly, the third term implies

$$Q^*_{i-1,j,k} = MQ^*_{\hat{i}-1,\hat{j},\hat{k}}$$

and the fifth and sixth terms imply

$$Q^*_{i,j\pm1,k} = MQ^*_{\hat{i},\hat{j}\pm,\hat{k}}$$

which, given equations (16)-(18), proves the symmetry of the intermediate step.

Consider next the discretized equation (12b) at the point (i,j,k)

$$\Delta^n Q_{i,j,k} + \Delta\tau\left([A^-\Delta^n Q]_{i+1,j,k} - [A^-\Delta^n Q]_{ij,k} + [C^+\Delta^n Q]_{ij,k} - [C^+\Delta^n Q]_{ij,k-1}\right.$$
$$\left. + [C^-\Delta^n Q]_{i,j,k+1} - [C^-\Delta^n Q]_{ij,k}\right) = Q^*_{i,jk} \qquad (24)$$

and at point $(\hat{i},\hat{j},\hat{k})$

$$\Delta^n Q_{\hat{i}\hat{j}\hat{k}} + \Delta\tau\left([A^-\Delta^n Q]_{\hat{i}+1,\hat{j}\hat{k}} - [A^-\Delta^n Q]_{\hat{i}\hat{j}\hat{k}} + [C^+\Delta^n Q]_{\hat{i}\hat{j}\hat{k}} - [C^+\Delta^n Q]_{\hat{i},\hat{j}\hat{k}-1}\right.$$
$$\left. + [C^-\Delta^n Q]_{\hat{i}\hat{j},\hat{k}+1} - [C^-\Delta^n Q]_{\hat{i}\hat{j}\hat{k}}\right) = Q^*_{\hat{i},\hat{j},\hat{k}} \qquad (25)$$

Pre-multiply equation (25) by M and use equation (14) to obtain

$$M\Delta^n Q_{\hat{i}\hat{j}\hat{k}} + \Delta\tau\left([MA^-\Delta^n Q]_{\hat{i}+1,\hat{j}\hat{k}} - [MA^-\Delta^n Q]_{\hat{i},\hat{j},\hat{k}} + [MC^+\Delta^n Q]_{\hat{i},\hat{j},\hat{k}}\right. \qquad (26)$$
$$\left. - [MC^+\Delta^n Q]_{\hat{i}\hat{j}\hat{k}-1} + [MC^-\Delta^n Q]_{\hat{i}\hat{j}\hat{k}+1} - [MC^-\Delta^n Q]_{\hat{i}\hat{j}\hat{k}}\right) = Q^*_{i,jk}$$

Using relations (16)-(19) in equation (26) gives

$$M\Delta^n Q_{\hat{i}\hat{j}\hat{k}} + \Delta\tau\left(A^-_{i+1,j,k}M\Delta^n Q_{\hat{i}+1\hat{j},\hat{k}} - A^-_{ij,k}M\Delta^n Q_{\hat{i}\hat{j},\hat{k}} - C^-_{i,jk}\Delta^n Q_{\hat{i}\hat{j}\hat{k}}\right. \qquad (27)$$
$$\left. + C^-_{i,j,k-1}M\Delta^n Q_{\hat{i}\hat{j}\hat{k}-1} - C^+_{ij,k+1}M\Delta^n Q_{\hat{i}\hat{j}\hat{k}+1} + C^+_{ij,k}M\Delta^n Q_{\hat{i}\hat{j}\hat{k}}\right) = Q^*_{i,jk}$$

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Subtracting equation (27) from equation (24) yields

$$[\Delta^n Q_{i,j,k} - M\Delta^n Q_{\hat{i},\hat{j},\hat{k}}] \tag{28}$$
$$+ \Delta\tau\Big(A^-_{i+1,j,k}[\Delta^n Q_{i+1,j,k} - M\Delta^n Q_{\hat{i}+1,\hat{j},\hat{k}}] - A^-_{i,j,k}[\Delta^n Q_{i,j,k} - M\Delta^n Q_{\hat{i},\hat{j},\hat{k}}]$$
$$- C^-_{i,j,k}[\Delta^n Q_{i,j,k} - M\Delta^n Q_{\hat{i},\hat{j},\hat{k}}] + C^-_{i,j,k+1}[\Delta^n Q_{i,j,k+1} - M\Delta^n Q_{\hat{i},\hat{j},\hat{k}-1}]$$
$$- C^+_{i,j,k-1}[\Delta^n Q_{i,j,k-1} - M\Delta^n Q_{\hat{i},\hat{j},\hat{k}+1}] + C^+_{i,j,k}[\Delta^n Q_{i,j,k} - M\Delta^n Q_{\hat{i},\hat{j},\hat{k}}]\Big) = 0$$

The first, third, fourth and seventh terms within brackets imply equation (15)

$$\Delta^n Q_{i,j,k} = M\Delta^n Q_{\hat{i}\hat{j}\hat{k}}$$

Similarly, the second term implies

$$\Delta^n Q_{i+1,j,k} = M\Delta^n Q_{\hat{i}+1\,\hat{j},\hat{k}}$$

and the fifth and sixth terms imply

$$\Delta^n Q_{i,j,k\pm1} = M\Delta^n Q_{\hat{i}\hat{j}\hat{k}\mp1}$$

which is what needs to be proved. Using logic similar to that above this property holds for all (i,j,k) in the linear system and the algorithm is found to be symmetric.

RHS Proof

Proof of symmetry for the RHS requires that equation (13) be demonstrated. The RHS discretization is detailed in the Numerical Method section as it is applied to the steady form of equation (1). It is quite clear from that discussion that the discretization is rather complicated, therefore, the symmetry of the flux terms for each direction are demonstrated separately. The ξ-direction term is relatively straightforward and requires no additional manipulation, however, the η and ζ-direction terms are much more involved and the MACSYMA system was utilized.

ξ- Direction

Recall that the ξ-direction flux term may be written

$$\frac{\partial F_i}{\partial \xi} = \frac{F_{i+1/2} - F_{i-1/2}}{\Delta \xi}$$

where

$$F_{i+1/2} = \frac{1}{2} \Big[F(Q_R) + F(Q_L) - |\tilde{A}|(Q_R - Q_L) \Big]_{i+1/2}$$

The conical Navier-Stokes solver employs a conical grid and the assumption that properties are constant in the ξ-direction. Therefore, $Q_R - Q_L = 0$ and the scheme reverts to simple central difference in this direction. However, it is important to recognize that the flux contribution is not zero since $F(Q_R) \neq F(Q_L)$ due to the grid. In addition, for the conical grid, equation (1) gives

$$F_i = \frac{1}{J} \begin{bmatrix} \rho U \\ \rho u\, U + \xi_x p \\ \rho v U \\ \rho w\, U \\ (e+p)U \end{bmatrix}$$

In which only w has opposite sign when comparing points (i,j,k) and $(\hat{i}\,\hat{j}\,\hat{k})$.

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It is therefore easy to see that

$$F_{i,j,k} = M F_{\hat{i}\hat{j}\hat{k}} \qquad (29)$$

Hence,

$$\left(\frac{\partial F_i}{\partial \xi} \right)_{i,j,k} = M \left(\frac{\partial F_i}{\partial \xi} \right)_{\hat{i},\hat{j},\hat{k}}$$

η-Direction

Unfortunately, it is not as easy to demonstrate symmetry for the η-direction. In this case we must show that

$$\left(\frac{\partial (G_i - S_v)}{\partial \eta} \right)_{i,j,k} = M \left(\frac{\partial (G_i - S_v)}{\partial \eta} \right)_{\hat{i}\hat{j}\hat{k}}$$

Recall that

$$\left(\frac{\partial G_i}{\partial \eta} \right)_{i,j,k} = \frac{G_{i,j+1/2,k} - G_{i,j-1/2,k}}{\Delta \eta}$$

and

$$G_{i,j+1/2,k} = \frac{1}{2} \left[G(Q_R) + G(Q_L) - |\tilde{B}|(Q_R - Q_L) \right] \qquad (30)$$

Then since $G_{i,j-1/2,k}$ is defined in a similar manner it is sufficient to show that

$$G_{i,j+1/2,k} = M G_{\hat{i}\hat{j}+1/2,\hat{k}} \qquad (31)$$

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and since central differences are used for the viscous terms

$$S_{v_{i,j,k}} = MS_{v_{\hat{i},\hat{j},\hat{k}}} \qquad (32)$$

The MACSYMA symbolic manipulation system was utilized to demonstrate these relations. However, even in this simplified form MACSYMA requires further simplification. This can be accomplished by first demonstrating

$$Q_{R_{ij+1/2,k}} = MQ_{R_{\hat{i}\hat{j}+1/2,\hat{k}}}$$
$$Q_{L_{ij+1/2,k}} = MQ_{L_{\hat{i}\hat{j}+1/2,\hat{k}}} \qquad (33)$$

and then using these results to prove equation (30). The proof is therefore separated into a proof of equation (33), followed by a proof of equation (31) and finally a proof of equation (32). These proofs are accomplished respectively through the MACSYMA scripts Gflux1.max, Gflux2.mac and Gflux3.mac whose recorded inputs and results are found in files Gflux1, Gflux2 and Gflux3 in Appendix A. Note that all of the MACSYMA routines are included in the appendix for clarity. In addition, all demonstrate a zero difference between the selected terms, therefore, symmetry is proved when a null vector or matrix results. The routines themselves were written based on the actual code using identical variable names. Because of this, a few variable names are used several times. The code variables are identified with the notation discussed earlier in the Numerical Method section. It should be clear that the proofs for each direction are sequential, therefore, the results from the first in a series are used in the following series.

Gflux1 proves that given

$$dq_{ij,k} = \Delta_{i,j+1/2,k} = Q_{ij+1,k} - Q_{i,jk} = M(Q_{\hat{i}\hat{j}+1,\hat{k}} - Q_{\hat{i}\hat{j}\hat{k}}) = M\Delta_{\hat{i}\hat{j}+1/2,\hat{k}} = M\,dq_{\hat{i}\hat{j}\hat{k}}$$
$$dqm1_{ij,k} = \Delta_{i,j-1/2,k} = Q_{ij,k} - Q_{ij-1,k} = M(Q_{\hat{i}\hat{j}\hat{k}} - Q_{\hat{i}\hat{j}-1,\hat{k}}) = M\Delta_{\hat{i}\hat{j}-1/2,\hat{k}} = M\,dqm1_{\hat{i}\hat{j}\hat{k}}$$
$$dqp1_{ij,k} = \Delta_{i,j+3/2,k} = Q_{ij+2,k} - Q_{ij+1,k} = M(Q_{\hat{i}\hat{j}+2,\hat{k}} - Q_{\hat{i}\hat{j}+1,\hat{k}}) = M\Delta_{\hat{i}\hat{j}+3/2,\hat{k}} = M\,dqp1_{\hat{i}\hat{j}\hat{k}}$$
$$qp_{ij,k} = Q_{R_{i,j+1/2,k}} = Q_{ij+1,k} = MQ_{\hat{i}\hat{j}+1,\hat{k}} = MQ_{R_{\hat{i}\hat{j}+1/2,\hat{k}}} = Mqp_{\hat{i}\hat{j}\hat{k}}$$
$$qm_{ij,k} = Q_{L_{i,j+1/2,k}} = Q_{i,jk} = MQ_{\hat{i}\hat{j},\hat{k}} = MQ_{L_{\hat{i}\hat{j}+1/2,\hat{k}}} = M\,qm_{\hat{i}\hat{j}\hat{k}}$$

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the following holds

$$spl_{i,j,k} = \hat{\Delta}_{ij+1/2,k} = M\hat{\Delta}_{\hat{i}\hat{j}+1/2\hat{k}} = M\,sp2_{\hat{i}\hat{j},\hat{k}}$$

$$sml_{i,j,k} = \tilde{\Delta}_{ij+1/2,k} = M\tilde{\Delta}_{\hat{i}\hat{j}+1/2\hat{k}} = M\,sm2_{\hat{i}\hat{j}\hat{k}}$$

Note that the variables qp, qm and dq are then overwritten in the code to form higher order expressions for Q_R and Q_L using

$$qp_{ijk} = Q_{ij+1k} - \frac{1}{2}spl_{ijk} = Q_{R_{ij+1/2,k}}$$

$$= M(Q_{\hat{i},\hat{j}+1,\hat{k}} - \frac{1}{2}sp2_{\hat{i}\hat{j}\hat{k}}) = MQ_{R_{\hat{i}\hat{j}+1/2,\hat{k}}}$$

$$qp_{ijk} = Mqp_{\hat{i}\hat{j}\hat{k}} \qquad\qquad (34)$$

and

$$qm_{ij,k} = Q_{ijk} + \frac{1}{2}sml_{ijk} = Q_{L_{ij+1/2,k}}$$

$$= M(Q_{\hat{i}\hat{j}\hat{k}} + \frac{1}{2}sm2_{\hat{i}\hat{j},\hat{k}}) = MQ_{L_{\hat{i}\hat{j}+1/2\hat{k}}}$$

$$qm_{ij,k} = Mqm_{\hat{i}\hat{j},\hat{k}} \qquad\qquad (35)$$

So that the symmetry relation for $dq = Q_R - Q_L$ is given by

$$dq_{ij,k} = qp_{ijk} - qm_{ij,k}$$
$$= M(qp_{\hat{i}\hat{j}\hat{k}} - qm_{\hat{i}\hat{j}\hat{k}})$$
$$= Mdq_{\hat{i}\hat{j}\hat{k}} \qquad\qquad (36)$$

Equations (34)-(36) are then used in Gflux2 to prove equation (31). Gflux3 completes the η-direction demonstrations by proving equation (32) using the variable gs in place of S_v.

ζ-Direction

The last direction is the most difficult because of the azimuthal ordering. It is easy to see that

$$k-2 \leftrightarrow \hat{k}+2$$
$$k-1 \leftrightarrow \hat{k}+1$$
$$k \leftrightarrow \hat{k}$$
$$k+1 \leftrightarrow \hat{k}-1$$
$$k+2 \leftrightarrow \hat{k}-2$$

Once again, the desired symmetry property is

$$\left(\frac{\partial H_i}{\partial \zeta}\right)_{i,j,k} = M\left(\frac{\partial H_i}{\partial \zeta}\right)_{\hat{i},\hat{j}\hat{k}}$$

where

$$\left(\frac{\partial H_i}{\partial \zeta}\right)_{ijk} = \frac{H_{ijk+1/2} - H_{ij,k-1/2}}{\Delta \zeta}$$

and Roe's FDS gives

$$H_{ij,k+1/2} = \frac{1}{2}\left[H(Q_R) + H(Q_L) - |\tilde{C}|(Q_R - Q_L)\right]_{jk+1/2} \qquad (37)$$

Therefore, the symmetry relation that must be proved is

$$H_{ijk+1/2} = -MH_{\hat{i},\hat{j},\hat{k}-1/2} \qquad (38)$$

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Once again, the first proof, Hflux1, shows that given

$$dq_{ij,k} = \Delta_{ij,k+1/2} = Q_{ij,k+1} - Q_{ij,k} = M(Q_{ij\hat{k}-1} - Q_{ij\hat{k}}) = -M\Delta_{ij\hat{k}-1/2} = -Mdq_{ij\hat{k}-1}$$

$$dqp1_{ij,k} = \Delta_{ij,k+3/2} = Q_{ij,k+2} - Q_{ij,k+1} = M(Q_{ij\hat{k}-2} - Q_{ij\hat{k}-1}) = -M\Delta_{ij,\hat{k}-3/2} = -Mdqm1_{ij\hat{k}-1}$$

$$dqm1_{ij,k} = \Delta_{ij,k-1/2} = Q_{ij,k} - Q_{ij,k-1} = M(Q_{ij\hat{k}} - Q_{ij\hat{k}+1}) = -M\Delta_{ij\hat{k}+1/2} = -Mdqp1_{ij\hat{k}-1}$$

$$qp_{ij,k} = Q_{ij,k+1} = MQ_{ij\hat{k}-1} = Mqm_{ij\hat{k}-1}$$

$$qm_{ijk} = Q_{ij,k} = MQ_{ij\hat{k}} = Mqp_{ij\hat{k}-1}$$

the following holds

$$spl_{ij,k} = \hat{\Delta}_{ij,k+1/2} = -M\hat{\Delta}_{i,j,\hat{k}-1/2} = -Msm2_{ij\hat{k}-1}$$

$$sml_{ij,k} = \tilde{\Delta}_{ij,k+1/2} = -M\tilde{\Delta}_{i,j,\hat{k}-1/2} = -Msp2_{ij\hat{k}-1}$$

Then since

$$qp_{ij,k} = Q_{ij,k+1} - \frac{1}{2}spl_{ij,k} = Q_{R_{ij,k+1/2}}$$

$$= M(Q_{ij\hat{k}-1} + \frac{1}{2}sm2_{i,j,\hat{k}-1}) = MQ_{L_{ij,\hat{k}-1/2}}$$

$$qp_{ij,k} = M\,qm_{i,j,\hat{k}-1} \qquad (39)$$

similarly

$$qm_{ij,k} = Q_{ij,k} + \frac{1}{2}sml_{ij,k}$$

$$= M(Q_{ij,k} - \frac{1}{2}sp2_{ij\hat{k}-1})$$

$$qm_{ij,k} = Mqp_{ij\hat{k}-1} \qquad (40)$$

So the symmetry relation for $dq = Q_R - Q_L$ is given by

$$dq_{i,j,k} = qp_{ijk} - qm_{i,j,k}$$
$$= M(qm_{i\hat{j}\hat{k}-1} - qp_{i\hat{j},\hat{k}-1})$$
$$= -Mdq_{i\hat{j}\hat{k}-1} \qquad (41)$$

Equations (39)-(41) are then used in Hflux2 to prove equation (38).

Equations (29), (31), (32) and (38) collectively prove equation (13) and symmetry is demonstrated from the RHS.

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LHS Proof

The LHS proof is somewhat simpler to describe because a major portion of it has been presented in the General Proof section. Equations (16) - (18) must be proved to demonstrate the symmetry of the LHS. IN addition, the expressions to be evaluated are considerably more complicated than their RHS counterparts. Because of this the eigenvalues were included in a less general form (i.e., without absolute values) for specific sub- and supersonic cases.

Again the MACSYMA symbolic manipulation routine was used and the resulting scripts are included in Appendix A. The files have the following naming convention

$$A^+_{ijk} M = M A^+_{\hat{i},\hat{j},\hat{k}}$$

- apsup   - supersonic
- apsub   - subsonic

$$A^-_{ijk} M = M A^-_{\hat{i},\hat{j},\hat{k}}$$

- amsup   - supersonic
- amsub   - subsonic

$$B^+_{ijk} M = M B^+_{\hat{i},\hat{j},\hat{k}}$$

- bpsup   - supersonic
- bpsub   - subsonic

$$B^-_{ijk} M = M B^-_{\hat{i},\hat{j},\hat{k}}$$

- bmsup   - supersonic
- bmsub   - subsonic

$$C^+_{ijk} M = -M C^-_{\hat{i},\hat{j},\hat{k}}$$

- ccsup1   - supersonic
- ccsub1   - subsonic

Note that only one set of identities must be shown for the ζ-direction since the inverse is included in those presented. It should be recognized that sub- and supersonic flows can occur in both the plus and minus coordinate directions. These cases were tested and identical results were obtained. They were deleted from the current report to save space. The interested reader can verify the proof by simple alterations to the MACSYMA scripts included in the appendix.

Given the above proofs the symmetry properties of the LHS are established and hence the algorithm is shown to be symmetric for conical grids.

Summary

The symmetry of a conical Navier-Stokes equation solver was proved through the use of analytical and symbolic techniques. The MACSYMA symbolic manipulation software was utilized. MACSYMA routines are included to allow the interested reader to verify the results.

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[Mac]   Macsyma Reference Manual Version 13, Symbolics (1988).

Appendix A

- GFLUX1

- GFLUX2

- GFLUX3

- HFLUX1

- HFLUX2

- APSUP

- APSUB

- AMSUP

- AMSUB

- BPSUP

- BPSUB

- BMSUP

- BMSUB

- CCSUP1

- CCSUB1

```
(C3)  diff:matrix([0],[0],[0],[0],[0])$
(C4)  g:matrix([0],[0],[0],[0],[0])$
(C5)  gijk:matrix([0],[0],[0],[0],[0])$
(C6)  ghatijk:matrix([0],[0],[0],[0],[0])$
(C7)  sp:matrix([0],[0],[0],[0],[0],[0])$
(C8)  null:matrix([0],[0],[0],[0],[0],[0])$
(C9)  xy2:matrix([0],[0],[0],[0],[0],[0])$
(C10) x2y:matrix([0],[0],[0],[0],[0],[0])$
(C11) xpy:matrix([0],[0],[0],[0],[0],[0])$
(C12) sp1:matrix([0],[0],[0],[0],[0],[0])$
(C13) sp2:matrix([0],[0],[0],[0],[0],[0])$
(C14) sm1:matrix([0],[0],[0],[0],[0],[0])$
(C15) sm2:matrix([0],[0],[0],[0],[0],[0])$
(C16) ax:etx$
(C17) ay:ety$
(C18) az:etz$
(C19) dq:matrix([rp1-r],[rup1-ru],[rvp1-rv],[rwp1-rw],[ep1-e],[pp1
-p])$
(C20) dqm1:matrix([r-rm1],[ru-rum1],[rv-rvm1],[rw-rwm1],[e-em1],[p
-pm1])$
(C21) dqp1:matrix([rp2-rp1],[rup2-rup1],[rvp2-rvp1],[rwp2-rwp1],[e
p2-ep1],[pp2-pp1])$
(C22) qp:matrix([rp1],[rup1],[rvp1],[rwp1],[ep1],[pp1])$
(C23) qm:matrix([r],[ru],[rv],[rw],[e],[p])$
(C24) for i: 1 thru 6 do
xy2[i]: dqm1[i]*(dq[i]*dq[i]+eps)$
(C25) for i:1 thru 6 do
x2y[i]: dq[i]*(dqm1[i]*dqm1[i]+eps)$
(C26) for i:1 thru 6 do
xpy[i]: dqm1[i]*dqm1[i] + dq[i]*dq[i]$
(C27) for i:1 thru 6 do
sm1[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C28) for i: 1 thru 6 do
xy2[i]: dqp1[i]*(dq[i]*dq[i]+eps)$
(C29) for i:1 thru 6 do
x2y[i]: dq[i]*(dqp1[i]*dqp1[i]+eps)$
(C30) for i:1 thru 6 do
xpy[i]: dqp1[i]*dqp1[i] + dq[i]*dq[i]$
(C31) for i:1 thru 6 do
sp1[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C32) m:matrix([1,0,0,0,0,0],[0,1,0,0,0,0],[0,0,1,0,0,0],[0,0,0,-1
,0,0],[0,0,0,0,1,0]
,[0,0,0,0,0,1])$
(C33) ax:etx$
(C34) ay:ety$
(C35) az:-etz$
(C36) dq:m.dq$
(C37) dqm1:m.dqm1$
(C38) dqp1:m.dqp1$
(C39) qp:m.qp$
(C40) qm:m.qm$
```

```
(C41) for i: 1 thru 6 do
xy2[i]: dqm1[i]*(dq[i]*dq[i]+eps)$
(C42) for i:1 thru 6 do
x2y[i]: dq[i]*(dqm1[i]*dqm1[i]+eps)$
(C43) for i:1 thru 6 do
xpy[i]: dqm1[i]*dqm1[i] + dq[i]*dq[i]$
(C44) for i:1 thru 6 do
sm2[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C45) for i: 1 thru 6 do
xy2[i]: dqp1[i]*(dq[i]*dq[i]+eps)$
(C46) for i:1 thru 6 do
x2y[i]: dq[i]*(dqp1[i]*dqp1[i]+eps)$
(C47) for i:1 thru 6 do
xpy[i]: dqp1[i]*dqp1[i] + dq[i]*dq[i]$
(C48) for i:1 thru 6 do
sp2[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C49) diff1:sp1-m.sp2$
(C50) diff1:ratexpand(diff1);
```

$$
(D50) \quad
\begin{bmatrix}
0 \\
\\
0 \\
\\
0 \\
\\
0 \\
\\
0 \\
\\
0 \\
\\
0 \\
\\
0
\end{bmatrix}
$$

```
(C51) diff2:sm1-m.sm2$
(C52) diff2:ratexpand(diff2);
```

$$
(D52) \quad
\begin{bmatrix}
0 \\
\\
0 \\
\\
0 \\
\\
0 \\
\\
0 \\
\\
0 \\
\\
0 \\
\\
0
\end{bmatrix}
$$

```
(C53) closefile(gflux1)$
```

```
(C3)  diff:matrix([0],[0],[0],[0],[0])$
(C4)  g:matrix([0],[0],[0],[0],[0])$
(C5)  gijk:matrix([0],[0],[0],[0],[0])$
(C6)  ghatijk:matrix([0],[0],[0],[0],[0])$
(C7)  sp:matrix([0],[0],[0],[0],[0],[0])$
(C8)  dq:matrix([0],[0],[0],[0],[0])$
(C9)  null:matrix([0],[0],[0],[0],[0],[0])$
(C10)  xy2:matrix([0],[0],[0],[0],[0],[0])$
(C11)  x2y:matrix([0],[0],[0],[0],[0],[0])$
(C12)  xpy:matrix([0],[0],[0],[0],[0],[0])$
(C13)  sp1:matrix([0],[0],[0],[0],[0])$
(C14)  sp2:matrix([0],[0],[0],[0],[0])$
(C15)  sm1:matrix([0],[0],[0],[0],[0])$
(C16)  sm2:matrix([0],[0],[0],[0],[0])$
(C17)  ax:etx$
(C18)  ay:ety$
(C19)  az:etz$
(C20)  axt:ax/sada$
(C21)  ayt:ay/sada$
(C22)  azt:az/sada$
(C23)  dq:matrix([dq1],[dq2],[dq3],[dq4],[dq5])$
(C24)  qp:matrix([qp1],[qp2],[qp3],[qp4],[qp5],[qp6])$
(C25)  qm:matrix([qm1],[qm2],[qm3],[qm4],[qm5],[qm6])$
(C26)  axt:ax/sada$
(C27)  ayt:ay/sada$
(C28)  azt:az/sada$
(C29)  e1:tt*sada$
(C30)  e4:e1+csad$
(C31)  e5:e1-csad$
(C32)  be1:matrix([0.5*(e1+abs(e1)),0,0,0,0],
[0,0.5*(e1+abs(e1)),0,0,0],
[0,0,0.5*(e1+abs(e1)),0,0],
[0,0,0,0.5*(e4+abs(e4)),0],
[0,0,0,0,0.5*(e5+abs(e5))])$
(C33)  be2:matrix([0.5*(e1-abs(e1)),0,0,0,0],
[0,0.5*(e1-abs(e1)),0,0,0],
[0,0,0.5*(e1-abs(e1)),0,0],
[0,0,0,0.5*(e4-abs(e4)),0],
[0,0,0,0,0.5*(e5-abs(e5))])$
(C34)  a:q1/(sqrt(2)*c)$
(C35)  c1:0.5*rqrq$
(C36)  c2:c*c/gm1$
(C37)  br:matrix([axt,ayt,azt,a,a],
[q2*axt,q2*ayt-q1*azt,q2*azt+q1*ayt,a*(q2+c*axt),a*(q2-c*axt)],
[q3*axt+q1*azt,q3*ayt,q3*azt-q1*axt,a*(q3+c*ayt),a*(q3-c*ayt)],
[q4*axt-q1*ayt,q4*ayt+q1*axt,q4*azt,a*(q4+c*azt),a*(q4-c*azt)],
[c1*axt+q1*(q3*azt-q4*ayt),c1*ayt+q1*(q4*axt-q2*azt),
c1*azt+q1*(q2*ayt-q3*axt),a*(c1+c2+c*tt),a*(c1+c2-c*tt)])$
(C38)  phi:0.5*gm1*rqrq$
(C39)  c2:c*c$
(C40)  b:1/(sqrt(2)*rc)$
```

```
(C41)  c1:1-phi/c2$
(C42)  c3:gm1/c2$
(C43)  bl:matrix([axt*c1+q6*(q4*ayt-q3*azt),axt*q2*c3,axt*q3*c3+azt
*q6,
axt*q4*c3-ayt*q6,-axt*c3],
[ayt*c1+q6*(q2*azt-q4*axt),ayt*q2*c3-azt*q6,ayt*q3*c3,
ayt*q4*c3+axt*q6,-ayt*c3],
[azt*c1+q6*(q3*axt-q2*ayt),azt*q2*c3+ayt*q6,azt*q3*c3-axt*q6,
azt*q4*c3,-azt*c3],
[b*(phi-c*tt),b*(c*axt-q2*gm1),b*(c*ayt-q3*gm1),b*(c*azt-q4*gm1),
b*gm1],
[b*(phi+c*tt),-b*(c*axt+q2*gm1),-b*(c*ayt+q3*gm1),-b*(c*azt+q4*gm1
),
b*gm1])$
(C44)  sp:bl.dq$
(C45)  sp2:be1.sp$
(C46)  sp:bl.dq$
(C47)  sm2:be2.sp$
(C48)  g:br.sm2-br.sp2$
(C49)  tl:(qm[2]*ax+qm[3]*ay+qm[4]*az)/qm[1]$
(C50)  g[1]:qm[1]*tl+g[1]$
(C51)  g[2]:qm[2]*tl+ax*qm[6]+g[2]$
(C52)  g[3]:qm[3]*tl+ay*qm[6]+g[3]$
(C53)  g[4]:qm[4]*tl+az*qm[6]+g[4]$
(C54)  g[5]:(qm[5]+qm[6])*tl+g[5]$
(C55)  tl:(qp[2]*ax+qp[3]*ay+qp[4]*az)/qp[1]$
(C56)  gijk[1]:0.5*(qp[1]*tl+g[1])$
(C57)  gijk[2]:0.5*(qp[2]*tl+ax*qp[6]+g[2])$
(C58)  gijk[3]:0.5*(qp[3]*tl+ay*qp[6]+g[3])$
(C59)  gijk[4]:0.5*(qp[4]*tl+az*qp[6]+g[4])$
(C60)  gijk[5]:0.5*((qp[5]+qp[6])*tl+g[5])$
(C61)  m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0
,0,0,0,1])$
(C62)  m2:matrix([1,0,0,0,0,0],[0,1,0,0,0,0],[0,0,1,0,0,0],[0,0,0,-
1,0,0],
[0,0,0,0,1,0],[0,0,0,0,0,1])$
(C63)  ax:etx$
(C64)  ay:ety$
(C65)  az:-etz$
(C66)  axt:ax/sada$
(C67)  ayt:ay/sada$
(C68)  azt:az/sada$
(C69)  rw:-rw$
(C70)  rwp1:-rwp1$
(C71)  rwp2:-rwp2$
(C72)  rwm1:-rwm1$
(C73)  dq:m.dq$
(C74)  qp:m2.qp$
(C75)  qm:m2.qm$
(C76)  q4:-q4$
(C77)  e1:tt*sada$
```

```
(C78)  e4:e1+csad$
(C79)  e5:e1-csad$
(C80)  be1:matrix([0.5*(e1+abs(e1)),0,0,0,0],
[0,0.5*(e1+abs(e1)),0,0,0],
[0,0,0.5*(e1+abs(e1)),0,0],
[0,0,0,0.5*(e4+abs(e4)),0],
[0,0,0,0,0.5*(e5+abs(e5))])$
(C81)  be2:matrix([0.5*(e1-abs(e1)),0,0,0,0],
[0,0.5*(e1-abs(e1)),0,0,0],
[0,0,0.5*(e1-abs(e1)),0,0],
[0,0,0,0.5*(e4-abs(e4)),0],
[0,0,0,0,0.5*(e5-abs(e5))])$
(C82)  a:q1/(sqrt(2)*c)$
(C83)  c1:0.5*rqrq$
(C84)  c2:c*c/gm1$
(C85)  br:matrix([axt,ayt,azt,a,a],
[q2*axt,q2*ayt-q1*azt,q2*azt+q1*ayt,a*(q2+c*axt),a*(q2-c*axt)],
[q3*axt+q1*azt,q3*ayt,q3*azt-q1*axt,a*(q3+c*ayt),a*(q3-c*ayt)],
[q4*axt-q1*ayt,q4*ayt+q1*axt,q4*azt,a*(q4+c*azt),a*(q4-c*azt)],
[c1*axt+q1*(q3*azt-q4*ayt),c1*ayt+q1*(q4*axt-q2*azt),
c1*azt+q1*(q2*ayt-q3*axt),a*(c1+c2+c*tt),a*(c1+c2-c*tt)])$
(C86)  phi:0.5*gm1*rqrq$
(C87)  c2:c*c$
(C88)  b:1/(sqrt(2)*rc)$
(C89)  c1:1-phi/c2$
(C90)  c3:gm1/c2$
(C91)  bl:matrix([axt*c1+q6*(q4*ayt-q3*azt),axt*q2*c3,axt*q3*c3+azt
*q6,
axt*q4*c3-ayt*q6,-axt*c3],
[ayt*c1+q6*(q2*azt-q4*axt),ayt*q2*c3-azt*q6,ayt*q3*c3,
ayt*q4*c3+axt*q6,-ayt*c3],
[azt*c1+q6*(q3*axt-q2*ayt),azt*q2*c3+ayt*q6,azt*q3*c3-axt*q6,
azt*q4*c3,-azt*c3],
[b*(phi-c*tt),b*(c*axt-q2*gm1),b*(c*ayt-q3*gm1),b*(c*azt-q4*gm1),
b*gm1],
[b*(phi+c*tt),-b*(c*axt+q2*gm1),-b*(c*ayt+q3*gm1),-b*(c*azt+q4*gm1
),
b*gm1])$
(C92)  sp:bl.dq$
(C93)  sp2:be1.sp$
(C94)  sp:bl.dq$
(C95)  sm2:be2.sp$
(C96)  g:br.sm2-br.sp2$
(C97)  tl:(qm[2]*ax+qm[3]*ay+qm[4]*az)/qm[1]$
(C98)  g[1]:qm[1]*tl+g[1]$
(C99)  g[2]:qm[2]*tl+ax*qm[6]+g[2]$
(C100)  g[3]:qm[3]*tl+ay*qm[6]+g[3]$
(C101)  g[4]:qm[4]*tl+az*qm[6]+g[4]$
(C102)  g[5]:(qm[5]+qm[6])*tl+g[5]$
(C103)  tl:(qp[2]*ax+qp[3]*ay+qp[4]*az)/qp[1]$
(C104)  ghatijk[1]:0.5*(qp[1]*tl+g[1])$
```

```
(C105) ghatijk[2]:0.5*(qp[2]*tl+ax*qp[6]+g[2])$
(C106) ghatijk[3]:0.5*(qp[3]*tl+ay*qp[6]+g[3])$
(C107) ghatijk[4]:0.5*(qp[4]*tl+az*qp[6]+g[4])$
(C108) ghatijk[5]:0.5*((qp[5]+qp[6])*tl+g[5])$
(C109) diff:gijk-m.ghatijk$
(C110) diff:ratexpand(diff);
```

$$
(D110) \quad
\begin{bmatrix}
0 \\
\\
0 \\
\\
0 \\
\\
0 \\
\\
0
\end{bmatrix}
$$

```
(C111) closefile(gflux2)$
```

```
(C3)   diff:matrix([0],[0],[0],[0],[0])$
(C4)   gsijk:matrix([0],[0],[0],[0],[0])$
(C5)   gshijk:matrix([0],[0],[0],[0],[0])$
(C6)   ax:etx$
(C7)   ay:ety$
(C8)   az:etz$
(C9)   axt:ax/sada$
(C10)  ayt:ay/sada$
(C11)  azt:az/sada$
(C12)  ra:.5*(r+rp1)$
(C13)  pa:.5*(p+pp1)$
(C14)  emu:(gam*abs(pa/ra))**0.666$
(C15)  cons:fsmach/rel$
(C16)  rpr:pr*emu$
(C17)  vav:0.5*(volp1+vol)$
(C18)  u2:rup1/rp1-ru/r$
(C19)  v2:rvp1/rp1-rv/r$
(C20)  w2:rwp1/rp1-rw/r$
(C21)  t2:gam*(pp1/rp1-p/r)$
(C22)  sigx:0.667*emu*cons*(2.*u2*ax-v2*ay-w2*az)/vav$
(C23)  sigy:0.667*emu*cons*(2.*v2*ay-u2*ax-w2*az)/vav$
(C24)  sigz:0.667*emu*cons*(2.*w2*az-u2*ax-v2*ay)/vav$
(C25)  txy:emu*cons*(u2*ay+v2*ax)/vav$
(C26)  txz:emu*cons*(u2*az+w2*ax)/vav$
(C27)  tyz:emu*cons*(v2*az+w2*ay)/vav$
(C28)  qx:-cons*rpr*rgm1*t2*ax/vav$
(C29)  qy:-cons*rpr*rgm1*t2*ay/vav$
(C30)  qz:-cons*rpr*rgm1*t2*az/vav$
(C31)  gsijk[1,1]:0.0$
(C32)  gsijk[2,1]:ax*sigx+ay*txy+az*txz$
(C33)  gsijk[3,1]:ax*txy+ay*sigy+az*tyz$
(C34)  gsijk[4,1]:ax*txz+ay*tyz+az*sigz$
(C35)  ua:0.5*(rup1/rp1+ru/r)$
(C36)  va:0.5*(rvp1/rp1+rv/r)$
(C37)  wa:0.5*(rwp1/rp1+rw/r)$
(C38)  gsijk[5,1]:ua*gsijk[2,1]+va*gsijk[3,1]+wa*gsijk[4,1]-qx*ax-q
y*ay-qz*az$
(C39)  m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0
,0,0,0,1])$
(C40)  ax:etx$
(C41)  ay:ety$
(C42)  az:-etz$
(C43)  axt:ax/sada$
(C44)  ayt:ay/sada$
(C45)  azt:az/sada$
(C46)  rw:-rw$
(C47)  rwp1:-rwp1$
(C48)  rwm1:-rwm1$
(C49)  ra:.5*(r+rp1)$
(C50)  pa:.5*(p+pp1)$
(C51)  emu:(gam*abs(pa/ra))**0.666$
```

```
(C52)  cons:fsmach/rel$
(C53)  rpr:pr*emu$
(C54)  vav:0.5*(volp1+vol)$
(C55)  u2:rup1/rp1-ru/r$
(C56)  v2:rvp1/rp1-rv/r$
(C57)  w2:rwp1/rp1-rw/r$
(C58)  t2:gam*(pp1/rp1-p/r)$
(C59)  sigx:0.667*emu*cons*(2.*u2*ax-v2*ay-w2*az)/vav$
(C60)  sigy:0.667*emu*cons*(2.*v2*ay-u2*ax-w2*az)/vav$
(C61)  sigz:0.667*emu*cons*(2.*w2*az-u2*ax-v2*ay)/vav$
(C62)  txy:emu*cons*(u2*ay+v2*ax)/vav$
(C63)  txz:emu*cons*(u2*az+w2*ax)/vav$
(C64)  tyz:emu*cons*(v2*az+w2*ay)/vav$
(C65)  qx:-cons*rpr*rgm1*t2*ax/vav$
(C66)  qy:-cons*rpr*rgm1*t2*ay/vav$
(C67)  qz:-cons*rpr*rgm1*t2*az/vav$
(C68)  gshijk[1,1]:0.0$
(C69)  gshijk[2,1]:ax*sigx+ay*txy+az*txz$
(C70)  gshijk[3,1]:ax*txy+ay*sigy+az*tyz$
(C71)  gshijk[4,1]:ax*txz+ay*tyz+az*sigz$
(C72)  ua:0.5*(rup1/rp1+ru/r)$
(C73)  va:0.5*(rvp1/rp1+rv/r)$
(C74)  wa:0.5*(rwp1/rp1+rw/r)$
(C75)  gshijk[5,1]:ua*gshijk[2,1]+va*gshijk[3,1]+wa*gshijk[4,1]-qx*
ax-qy*ay-qz*az$
(C76)  diff:gsijk-m.gshijk$
(C77)  diff:ratexpand(diff);
```

```
                                            [ 0 ]
                                            [   ]
                                            [ 0 ]
                                            [   ]
(D77)                                       [ 0 ]
                                            [   ]
                                            [ 0 ]
                                            [   ]
                                            [ 0 ]
                                            [   ]
                                            [ 0 ]
```

```
(C78)  closefile(gflux3)$
```

```
(C3)  diff:matrix([0],[0],[0],[0],[0])$
(C4)  h:matrix([0],[0],[0],[0],[0])$
(C5)  hijk:matrix([0],[0],[0],[0],[0])$
(C6)  hhatijk:matrix([0],[0],[0],[0],[0])$
(C7)  null:matrix([0],[0],[0],[0],[0],[0])$
(C8)  xy2:matrix([0],[0],[0],[0],[0],[0])$
(C9)  x2y:matrix([0],[0],[0],[0],[0],[0])$
(C10) xpy:matrix([0],[0],[0],[0],[0],[0])$
(C11) sp1:matrix([0],[0],[0],[0],[0],[0])$
(C12) sp2:matrix([0],[0],[0],[0],[0],[0])$
(C13) sm1:matrix([0],[0],[0],[0],[0],[0])$
(C14) sm2:matrix([0],[0],[0],[0],[0],[0])$
(C15) ax:ztx$
(C16) ay:zty$
(C17) az:ztz$
(C18) dq:matrix([rp1-r],[rup1-ru],[rvp1-rv],[rwp1-rw],[ep1-e],[pp1
-p])$
(C19) dqm1:matrix([r-rm1],[ru-rum1],[rv-rvm1],[rw-rwm1],[e-em1],[p
-pm1])$
(C20) dqp1:matrix([rp2-rp1],[rup2-rup1],[rvp2-rvp1],[rwp2-rwp1],[e
p2-ep1],[pp2-pp1])$
(C21) qp:matrix([rp1],[rup1],[rvp1],[rwp1],[ep1],[pp1])$
(C22) qm:matrix([r],[ru],[rv],[rw],[e],[p])$
(C23) for i: 1 thru 6 do
xy2[i]: dqm1[i]*(dq[i]*dq[i]+eps)$
(C24) for i:1 thru 6 do
x2y[i]: dq[i]*(dqm1[i]*dqm1[i]+eps)$
(C25) for i:1 thru 6 do
xpy[i]: dqm1[i]*dqm1[i] + dq[i]*dq[i]$
(C26) for i:1 thru 6 do
sm1[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C27) for i: 1 thru 6 do
xy2[i]: dqp1[i]*(dq[i]*dq[i]+eps)$
(C28) for i:1 thru 6 do
x2y[i]: dq[i]*(dqp1[i]*dqp1[i]+eps)$
(C29) for i:1 thru 6 do
xpy[i]: dqp1[i]*dqp1[i] + dq[i]*dq[i]$
(C30) for i:1 thru 6 do
sp1[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C31) m:matrix([1,0,0,0,0,0],[0,1,0,0,0,0],[0,0,1,0,0,0],[0,0,0,-1
,0,0],[0,0,0,0,1,0]
,[0,0,0,0,0,1])$
(C32) ax:-ztx$
(C33) ay:-zty$
(C34) az:ztz$
(C35) dqo:dq$
(C36) dqm1o:dqm1$
(C37) dqp1o:dqp1$
(C38) qpo:qp$
(C39) qmo:qm$
(C40) dq:-M.dqo$
```

```
(C41)  dqm1:-M.dqp1o$
(C42)  dqp1:-M.dqm1o$
(C43)  qp:M.qm$
(C44)  qm:M.qp$
(C45)  for i: 1 thru 6 do
xy2[i]: dqm1[i]*(dq[i]*dq[i]+eps)$
(C46)  for i:1 thru 6 do
x2y[i]: dq[i]*(dqm1[i]*dqm1[i]+eps)$
(C47)  for i:1 thru 6 do
xpy[i]: dqm1[i]*dqm1[i] + dq[i]*dq[i]$
(C48)  for i:1 thru 6 do
sm2[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C49)  for i: 1 thru 6 do
xy2[i]: dqp1[i]*(dq[i]*dq[i]+eps)$
(C50)  for i:1 thru 6 do
x2y[i]: dq[i]*(dqp1[i]*dqp1[i]+eps)$
(C51)  for i:1 thru 6 do
xpy[i]: dqp1[i]*dqp1[i] + dq[i]*dq[i]$
(C52)  for i:1 thru 6 do
sp2[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C53)  diff1:sp1+m.sm2$
(C54)  diff1:ratexpand(diff1);
```

$$(D54) \quad \begin{bmatrix} 0 \\ \\ 0 \\ \\ 0 \\ \\ 0 \\ \\ 0 \\ \\ 0 \\ \\ 0 \end{bmatrix}$$

```
(C55)  diff2:sm1+m.sp2$
(C56)  diff2:ratexpand(diff2);
```

$$(D56) \quad \begin{bmatrix} 0 \\ \\ 0 \\ \\ 0 \\ \\ 0 \\ \\ 0 \\ \\ 0 \\ \\ 0 \end{bmatrix}$$

```
(C57)  closefile(hflux1)$
```

```
(C3)   diff:matrix([0],[0],[0],[0],[0])$
(C4)   h:matrix([0],[0],[0],[0],[0])$
(C5)   hijk:matrix([0],[0],[0],[0],[0])$
(C6)   hhatijk:matrix([0],[0],[0],[0],[0])$
(C7)   sp:matrix([0],[0],[0],[0],[0],[0])$
(C8)   dq:matrix([0],[0],[0],[0],[0])$
(C9)   null:matrix([0],[0],[0],[0],[0],[0])$
(C10)  xy2:matrix([0],[0],[0],[0],[0],[0])$
(C11)  x2y:matrix([0],[0],[0],[0],[0],[0])$
(C12)  xpy:matrix([0],[0],[0],[0],[0],[0])$
(C13)  sp1:matrix([0],[0],[0],[0],[0])$
(C14)  sp2:matrix([0],[0],[0],[0],[0])$
(C15)  sm1:matrix([0],[0],[0],[0],[0])$
(C16)  sm2:matrix([0],[0],[0],[0],[0])$
(C17)  ax:ztx$
(C18)  ay:zty$
(C19)  az:ztz$
(C20)  axt:ax/sada$
(C21)  ayt:ay/sada$
(C22)  azt:az/sada$
(C23)  dq:matrix([dq1],[dq2],[dq3],[dq4],[dq5])$
(C24)  qp:matrix([qp1],[qp2],[qp3],[qp4],[qp5],[qp6])$
(C25)  qm:matrix([qm1],[qm2],[qm3],[qm4],[qm5],[qm6])$
(C26)  e1:tt*sada$
(C27)  e4:e1+csad$
(C28)  e5:e1-csad$
(C29)  be1:matrix([0.5*(e1+abs(e1)),0,0,0,0],
[0,0.5*(e1+abs(e1)),0,0,0],
[0,0,0.5*(e1+abs(e1)),0,0],
[0,0,0,0.5*(e4+abs(e4)),0],
[0,0,0,0,0.5*(e5+abs(e5))])$
(C30)  be2:matrix([0.5*(e1-abs(e1)),0,0,0,0],
[0,0.5*(e1-abs(e1)),0,0,0],
[0,0,0.5*(e1-abs(e1)),0,0],
[0,0,0,0.5*(e4-abs(e4)),0],
[0,0,0,0,0.5*(e5-abs(e5))])$
(C31)  a:q1/(sqrt(2)*c)$
(C32)  c1:0.5*rqrq$
(C33)  c2:c*c/gm1$
(C34)  br:matrix([axt,ayt,azt,a,a],
[q2*axt,q2*ayt-q1*azt,q2*azt+q1*ayt,a*(q2+c*axt),a*(q2-c*axt)],
[q3*axt+q1*azt,q3*ayt,q3*azt-q1*axt,a*(q3+c*ayt),a*(q3-c*ayt)],
[q4*axt-q1*ayt,q4*ayt+q1*axt,q4*azt,a*(q4+c*azt),a*(q4-c*azt)],
[c1*axt+q1*(q3*azt-q4*ayt),c1*ayt+q1*(q4*axt-q2*azt),
c1*azt+q1*(q2*ayt-q3*axt),a*(c1+c2+c*tt),a*(c1+c2-c*tt)])$
(C35)  phi:0.5*gm1*rqrq$
(C36)  c2:c*c$
(C37)  b:1/(sqrt(2)*rc)$
(C38)  c1:1-phi/c2$
(C39)  c3:gm1/c2$
(C40)  bl:matrix([axt*c1+q6*(q4*ayt-q3*azt),axt*q2*c3,axt*q3*c3+azt
```

```
*q6,
axt*q4*c3-ayt*q6,-axt*c3],
[ayt*c1+q6*(q2*azt-q4*axt),ayt*q2*c3-azt*q6,ayt*q3*c3,
ayt*q4*c3+axt*q6,-ayt*c3],
[azt*c1+q6*(q3*axt-q2*ayt),azt*q2*c3+ayt*q6,azt*q3*c3-axt*q6,
azt*q4*c3,-azt*c3],
[b*(phi-c*tt),b*(c*axt-q2*gm1),b*(c*ayt-q3*gm1),b*(c*azt-q4*gm1),
b*gm1],
[b*(phi+c*tt),-b*(c*axt+q2*gm1),-b*(c*ayt+q3*gm1),-b*(c*azt+q4*gm1
),
b*gm1])$
(C41)  sp:bl.dq$
(C42)  sp2:be1.sp$
(C43)  sp:bl.dq$
(C44)  sm2:be2.sp$
(C45)  h:br.sm2-br.sp2$
(C46)  tl:(qm[2]*ax+qm[3]*ay+qm[4]*az)/qm[1]$
(C47)  h[1]:qm[1]*tl+h[1]$
(C48)  h[2]:qm[2]*tl+ax*qm[6]+h[2]$
(C49)  h[3]:qm[3]*tl+ay*qm[6]+h[3]$
(C50)  h[4]:qm[4]*tl+az*qm[6]+h[4]$
(C51)  h[5]:(qm[5]+qm[6])*tl+h[5]$
(C52)  tl:(qp[2]*ax+qp[3]*ay+qp[4]*az)/qp[1]$
(C53)  hijk[1]:0.5*(qp[1]*tl+h[1])$
(C54)  hijk[2]:0.5*(qp[2]*tl+ax*qp[6]+h[2])$
(C55)  hijk[3]:0.5*(qp[3]*tl+ay*qp[6]+h[3])$
(C56)  hijk[4]:0.5*(qp[4]*tl+az*qp[6]+h[4])$
(C57)  hijk[5]:0.5*((qp[5]+qp[6])*tl+h[5])$
(C58)  m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0
,0,0,0,1])$
(C59)  m2:matrix([1,0,0,0,0,0],[0,1,0,0,0,0],[0,0,1,0,0,0],[0,0,0,-
1,0,0],
[0,0,0,0,1,0],[0,0,0,0,0,1])$
(C60)  ax:-ztx$
(C61)  ay:-zty$
(C62)  az:ztz$
(C63)  axt:ax/sada$
(C64)  ayt:ay/sada$
(C65)  azt:az/sada$
(C66)  dqo:dq$
(C67)  qpo:qp$
(C68)  qmo:qm$
(C69)  dq:-m.dqo$
(C70)  qp:m2.qmo$
(C71)  qm:m2.qpo$
(C72)  q4:-q4$
(C73)  tt:-tt$
(C74)  e1:tt*sada$
(C75)  e4:e1+csad$
(C76)  e5:e1-csad$
(C77)  be1:matrix([0.5*(e1+abs(e1)),0,0,0,0],
```

```
[0,0.5*(e1+abs(e1)),0,0,0],
[0,0,0.5*(e1+abs(e1)),0,0],
[0,0,0,0.5*(e4+abs(e4)),0],
[0,0,0,0,0.5*(e5+abs(e5))]])$
(C78) be2:matrix([0.5*(e1-abs(e1)),0,0,0,0],
[0,0.5*(e1-abs(e1)),0,0,0],
[0,0,0.5*(e1-abs(e1)),0,0],
[0,0,0,0.5*(e4-abs(e4)),0],
[0,0,0,0,0.5*(e5-abs(e5))]])$
(C79) a:q1/(sqrt(2)*c)$
(C80) c1:0.5*rqrq$
(C81) c2:c*c/gm1$
(C82) br:matrix([axt,ayt,azt,a,a],
[q2*axt,q2*ayt-q1*azt,q2*azt+q1*ayt,a*(q2+c*axt),a*(q2-c*axt)],
[q3*axt+q1*azt,q3*ayt,q3*azt-q1*axt,a*(q3+c*ayt),a*(q3-c*ayt)],
[q4*axt-q1*ayt,q4*ayt+q1*axt,q4*azt,a*(q4+c*azt),a*(q4-c*azt)],
[c1*axt+q1*(q3*azt-q4*ayt),c1*ayt+q1*(q4*axt-q2*azt),
c1*azt+q1*(q2*ayt-q3*axt),a*(c1+c2+c*tt),a*(c1+c2-c*tt)]])$
(C83) phi:0.5*gm1*rqrq$
(C84) c2:c*c$
(C85) b:1/(sqrt(2)*rc)$
(C86) c1:1-phi/c2$
(C87) c3:gm1/c2$
(C88) bl:matrix([axt*c1+q6*(q4*ayt-q3*azt),axt*q2*c3,axt*q3*c3+azt
*q6,
axt*q4*c3-ayt*q6,-axt*c3],
[ayt*c1+q6*(q2*azt-q4*axt),ayt*q2*c3-azt*q6,ayt*q3*c3,
ayt*q4*c3+axt*q6,-ayt*c3],
[azt*c1+q6*(q3*axt-q2*ayt),azt*q2*c3+ayt*q6,azt*q3*c3-axt*q6,
azt*q4*c3,-azt*c3],
[b*(phi-c*tt),b*(c*axt-q2*gm1),b*(c*ayt-q3*gm1),b*(c*azt-q4*gm1),
b*gm1],
[b*(phi+c*tt),-b*(c*axt+q2*gm1),-b*(c*ayt+q3*gm1),-b*(c*azt+q4*gm1
),
b*gm1])$
(C89) sp:bl.dq$
(C90) sp2:be1.sp$
(C91) sp:bl.dq$
(C92) sm2:be2.sp$
(C93) h:br.sm2-br.sp2$
(C94) tl:(qm[2]*ax+qm[3]*ay+qm[4]*az)/qm[1]$
(C95) h[1]:qm[1]*tl+h[1]$
(C96) h[2]:qm[2]*tl+ax*qm[6]+h[2]$
(C97) h[3]:qm[3]*tl+ay*qm[6]+h[3]$
(C98) h[4]:qm[4]*tl+az*qm[6]+h[4]$
(C99) h[5]:(qm[5]+qm[6])*tl+h[5]$
(C100) tl:(qp[2]*ax+qp[3]*ay+qp[4]*az)/qp[1]$
(C101) hhatijk[1]:0.5*(qp[1]*tl+h[1])$
(C102) hhatijk[2]:0.5*(qp[2]*tl+ax*qp[6]+h[2])$
(C103) hhatijk[3]:0.5*(qp[3]*tl+ay*qp[6]+h[3])$
(C104) hhatijk[4]:0.5*(qp[4]*tl+az*qp[6]+h[4])$
```

```
(C105) hhatijk[5]:0.5*((qp[5]+qp[6])*tl+h[5])$
(C106) diff:hijk+m.hhatijk$
(C107) diff:ratexpand(diff);
```

$$
(D107) \quad \begin{bmatrix} 0 \\ \\ 0 \\ \\ 0 \\ \\ 0 \\ \\ 0 \end{bmatrix}
$$

```
(C108) closefile(hflux2)$
```

```
(C3)  ap1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4)  ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5)  m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C6)  diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C7)  sign:1$
(C8)  cgg1:(gam-1)/gam$
(C9)  cgg2:1/(2*gam)$
(C10)  xiy:0.0$
(C11)  xiz:0.0$
(C12)  sada:sqrt(xix**2+xiy**2+xiz**2)$
(C13)  axt:xix/sada$
(C14)  ayt:xiy/sada$
(C15)  azt:xiz/sada$
(C16)  rqrq:q2**2+q3**2+q4**2$
(C17)  q6:1/q1$
(C18)  pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C19)  prgam:pr*gam$
(C20)  pp:q5+pr$
(C21)  c:sqrt(prgam*q6)$
(C22)  tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C23)  rc:q1*c$
(C24)  csad:c*sada$
(C25)  e1:tt*sada$
(C26)  e4:e1+csad$
(C27)  e5:e1-csad$
(C28)  ev1:0.5*(e1+sign*abs(e1))$
(C29)  ev4:0.5*(e4+sign*abs(e4))$
(C30)  ev5:0.5*(e5+sign*abs(e5))$
(C31)  cg1:cgg1$
(C32)  cg2:cgg2$
(C33)  cg3:cgg2$
(C34)  d1q1:-ev1*q6$
(C35)  d1q2:xix*q6$
(C36)  d1q3:xiy*q6$
(C37)  d1q4:xiz*q6$
(C38)  d1q5:0.0$
(C39)  coe:gam*(gam-1)/(2*rc)$
(C40)  gm1q6:(gam-1)*q6$
(C41)  drcq1:coe*q5$
(C42)  drcq2:-coe*q2$
(C43)  drcq3:-coe*q3$
(C44)  drcq4:-coe*q4$
(C45)  drcq5:coe*q1$
(C46)  dcq1:(drcq1-c)*q6$
(C47)  dcq2:drcq2*q6$
(C48)  dcq3:drcq3*q6$
(C49)  dcq4:drcq4*q6$
```

```
(C50)   dcq5:drcq5*q6$
(C51)   depq1:0.5*gm1q6*rqrq*q6$
(C52)   depq2:-q2*gm1q6$
(C53)   depq3:-q3*gm1q6$
(C54)   depq4:-q4*gm1q6$
(C55)   depq5:gam$
(C56)   dttq1:-tt*q6$
(C57)   dttq2:axt*q6$
(C58)   dttq3:ayt*q6$
(C59)   dttq4:azt*q6$
(C60)   dttq5:0.0$
(C61)   d4q1:sada*(dttq1+dcq1)$
(C62)   d4q2:sada*(dttq2+dcq2)$
(C63)   d4q3:sada*(dttq3+dcq3)$
(C64)   d4q4:sada*(dttq4+dcq4)$
(C65)   d4q5:sada*dcq5$
(C66)   d5q1:sada*(dttq1-dcq1)$
(C67)   d5q2:sada*(dttq2-dcq2)$
(C68)   d5q3:sada*(dttq3-dcq3)$
(C69)   d5q4:sada*(dttq4-dcq4)$
(C70)   d5q5:-d4q5$
(C71)   a411:ev4+q1*d4q1$
(C72)   a511:ev5+q1*d5q1$
(C73)   ap1[1,1]:cg2*a411+cg3*a511$
(C74)   ap1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C75)   ap1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C76)   ap1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C77)   ap1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C78)   rcaxt:rc*axt$
(C79)   ev4ax:ev4*axt$
(C80)   ev5ax:ev5*axt$
(C81)   coe1:q2+rcaxt$
(C82)   coe:q2-rcaxt$
(C83)   a121:q2*d1q1$
(C84)   a421:ev4ax*drcq1+coe1*d4q1$
(C85)   a521:-ev5ax*drcq1+coe*d5q1$
(C86)   ap1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C87)   a122:q2*d1q2+ev1$
(C88)   a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C89)   a522:ev5-ev5ax*drcq2+coe*d5q2$
(C90)   ap1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C91)   a123:q2*d1q3$
(C92)   a423:ev4ax*drcq3+coe1*d4q3$
(C93)   a523:-ev5ax*drcq3+coe*d5q3$
(C94)   ap1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C95)   a124:q2*d1q4$
(C96)   a424:ev4ax*drcq4+coe1*d4q4$
(C97)   a524:-ev5ax*drcq4+coe*d5q4$
(C98)   ap1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C99)   a125:q2*d1q5$
(C100)  a425:ev4ax*drcq5+coe1*d4q5$
```

```
(C101)  a525:-ev5ax*drcq5+coe*d5q5$
(C102)  ap1[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C103)  rcayt:rc*ayt$
(C104)  ev4ay:ev4*ayt$
(C105)  ev5ay:ev5*ayt$
(C106)  coe1:q3+rcayt$
(C107)  coe:q3-rcayt$
(C108)  a131:q3*d1q1$
(C109)  a431:ev4ay*drcq1+coe1*d4q1$
(C110)  a531:-ev5ay*drcq1+coe*d5q1$
(C111)  ap1[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C112)  a132:q3*d1q2$
(C113)  a432:ev4ay*drcq2+coe1*d4q2$
(C114)  a532:-ev5ay*drcq2+coe*d5q2$
(C115)  ap1[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C116)  a133:q3*d1q3+ev1$
(C117)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C118)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C119)  ap1[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C120)  a134:q3*d1q4$
(C121)  a434:ev4ay*drcq4+coe1*d4q4$
(C122)  a534:-ev5ay*drcq4+coe*d5q4$
(C123)  ap1[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C124)  a135:q3*d1q5$
(C125)  a435:ev4ay*drcq5+coe1*d4q5$
(C126)  a535:-ev5ay*drcq5+coe*d5q5$
(C127)  ap1[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C128)  rcazt:rc*azt$
(C129)  ev4az:ev4*azt$
(C130)  ev5az:ev5*azt$
(C131)  coe1:q4+rcazt$
(C132)  coe:q4-rcazt$
(C133)  a141:q4*d1q1$
(C134)  a441:ev4az*drcq1+coe1*d4q1$
(C135)  a541:-ev5az*drcq1+coe*d5q1$
(C136)  ap1[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C137)  a142:q4*d1q2$
(C138)  a442:ev4az*drcq2+coe1*d4q2$
(C139)  a542:-ev5az*drcq2+coe*d5q2$
(C140)  ap1[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C141)  a143:q4*d1q3$
(C142)  a443:ev4az*drcq3+coe1*d4q3$
(C143)  a543:-ev5az*drcq3+coe*d5q3$
(C144)  ap1[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C145)  a144:q4*d1q4+ev1$
(C146)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C147)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C148)  ap1[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C149)  a145:q4*d1q5$
(C150)  a445:ev4az*drcq5+coe1*d4q5$
(C151)  a545:-ev5az*drcq5+coe*d5q5$
```

```
(C152)  ap1[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C153)  rctt:rc*tt$
(C154)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C155)  rt:rc*dttq1+tt*drcq1$
(C156)  a151:2*coe*d1q1$
(C157)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C158)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C159)  ap1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C160)  rt:rc*dttq2+tt*drcq2$
(C161)  a152:coe*d1q2-d1q1*q2$
(C162)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C163)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C164)  ap1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C165)  rt:rc*dttq3+tt*drcq3$
(C166)  a153:coe*d1q3-d1q1*q3$
(C167)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C168)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C169)  ap1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C170)  rt:rc*dttq4+tt*drcq4$
(C171)  a154:coe*d1q4-d1q1*q4$
(C172)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C173)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C174)  ap1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C175)  rt:tt*drcq5$
(C176)  a155:coe*d1q5$
(C177)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C178)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C179)  ap1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C180)  q1:q1$
(C181)  q2:q2$
(C182)  q3:q3$
(C183)  q4:-q4$
(C184)  q5:q5$
(C185)  sign:1$
(C186)  cgg1:(gam-1)/gam$
(C187)  cgg2:1/(2*gam)$
(C188)  sada:sqrt(xix**2+xiy**2+xiz**2)$
(C189)  axt:xix/sada$
(C190)  ayt:xiy/sada$
(C191)  azt:xiz/sada$
(C192)  rqrq:q2**2+q3**2+q4**2$
(C193)  q6:1/q1$
(C194)  pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195)  prgam:pr*gam$
(C196)  pp:q5+pr$
(C197)  c:sqrt(prgam*q6)$
(C198)  tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199)  rc:q1*c$
(C200)  csad:c*sada$
(C201)  e1:tt*sada$
(C202)  e4:e1+csad$
```

```
(C203)  e5:e1-csad$
(C204)  ev1:0.5*(e1+sign*abs(e1))$
(C205)  ev4:0.5*(e4+sign*abs(e4))$
(C206)  ev5:0.5*(e5+sign*abs(e5))$
(C207)  cg1:cgg1$
(C208)  cg2:cgg2$
(C209)  cg3:cgg2$
(C210)  d1q1:-ev1*q6$
(C211)  d1q2:xix*q6$
(C212)  d1q3:xiy*q6$
(C213)  d1q4:xiz*q6$
(C214)  d1q5:0.0$
(C215)  coe:gam*(gam-1)/(2*rc)$
(C216)  gm1q6:(gam-1)*q6$
(C217)  drcq1:coe*q5$
(C218)  drcq2:-coe*q2$
(C219)  drcq3:-coe*q3$
(C220)  drcq4:-coe*q4$
(C221)  drcq5:coe*q1$
(C222)  dcq1:(drcq1-c)*q6$
(C223)  dcq2:drcq2*q6$
(C224)  dcq3:drcq3*q6$
(C225)  dcq4:drcq4*q6$
(C226)  dcq5:drcq5*q6$
(C227)  depq1:0.5*gm1q6*rqrq*q6$
(C228)  depq2:-q2*gm1q6$
(C229)  depq3:-q3*gm1q6$
(C230)  depq4:-q4*gm1q6$
(C231)  depq5:gam$
(C232)  dttq1:-tt*q6$
(C233)  dttq2:axt*q6$
(C234)  dttq3:ayt*q6$
(C235)  dttq4:azt*q6$
(C236)  dttq5:0.0$
(C237)  d4q1:sada*(dttq1+dcq1)$
(C238)  d4q2:sada*(dttq2+dcq2)$
(C239)  d4q3:sada*(dttq3+dcq3)$
(C240)  d4q4:sada*(dttq4+dcq4)$
(C241)  d4q5:sada*dcq5$
(C242)  d5q1:sada*(dttq1-dcq1)$
(C243)  d5q2:sada*(dttq2-dcq2)$
(C244)  d5q3:sada*(dttq3-dcq3)$
(C245)  d5q4:sada*(dttq4-dcq4)$
(C246)  d5q5:-d4q5$
(C247)  a411:ev4+q1*d4q1$
(C248)  a511:ev5+q1*d5q1$
(C249)  ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
        [0,0,0,0,0])$
(C250)  ap2[1,1]:cg2*a411+cg3*a511$
(C251)  ap2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C252)  ap2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
```

```
(C253)  ap2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C254)  ap2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C255)  rcaxt:rc*axt$
(C256)  ev4ax:ev4*axt$
(C257)  ev5ax:ev5*axt$
(C258)  coe1:q2+rcaxt$
(C259)  coe:q2-rcaxt$
(C260)  a121:q2*d1q1$
(C261)  a421:ev4ax*drcq1+coe1*d4q1$
(C262)  a521:-ev5ax*drcq1+coe*d5q1$
(C263)  ap2[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C264)  a122:q2*d1q2+ev1$
(C265)  a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C266)  a522:ev5-ev5ax*drcq2+coe*d5q2$
(C267)  ap2[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C268)  a123:q2*d1q3$
(C269)  a423:ev4ax*drcq3+coe1*d4q3$
(C270)  a523:-ev5ax*drcq3+coe*d5q3$
(C271)  ap2[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C272)  a124:q2*d1q4$
(C273)  a424:ev4ax*drcq4+coe1*d4q4$
(C274)  a524:-ev5ax*drcq4+coe*d5q4$
(C275)  ap2[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C276)  a125:q2*d1q5$
(C277)  a425:ev4ax*drcq5+coe1*d4q5$
(C278)  a525:-ev5ax*drcq5+coe*d5q5$
(C279)  ap2[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C280)  rcayt:rc*ayt$
(C281)  ev4ay:ev4*ayt$
(C282)  ev5ay:ev5*ayt$
(C283)  coe1:q3+rcayt$
(C284)  coe:q3-rcayt$
(C285)  a131:q3*d1q1$
(C286)  a431:ev4ay*drcq1+coe1*d4q1$
(C287)  a531:-ev5ay*drcq1+coe*d5q1$
(C288)  ap2[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C289)  a132:q3*d1q2$
(C290)  a432:ev4ay*drcq2+coe1*d4q2$
(C291)  a532:-ev5ay*drcq2+coe*d5q2$
(C292)  ap2[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C293)  a133:q3*d1q3+ev1$
(C294)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C295)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C296)  ap2[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C297)  a134:q3*d1q4$
(C298)  a434:ev4ay*drcq4+coe1*d4q4$
(C299)  a534:-ev5ay*drcq4+coe*d5q4$
(C300)  ap2[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C301)  a135:q3*d1q5$
(C302)  a435:ev4ay*drcq5+coe1*d4q5$
(C303)  a535:-ev5ay*drcq5+coe*d5q5$
```

```
(C304)  ap2[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C305)  rcazt:rc*azt$
(C306)  ev4az:ev4*azt$
(C307)  ev5az:ev5*azt$
(C308)  coe1:q4+rcazt$
(C309)  coe:q4-rcazt$
(C310)  a141:q4*d1q1$
(C311)  a441:ev4az*drcq1+coe1*d4q1$
(C312)  a541:-ev5az*drcq1+coe*d5q1$
(C313)  ap2[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C314)  a142:q4*d1q2$
(C315)  a442:ev4az*drcq2+coe1*d4q2$
(C316)  a542:-ev5az*drcq2+coe*d5q2$
(C317)  ap2[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C318)  a143:q4*d1q3$
(C319)  a443:ev4az*drcq3+coe1*d4q3$
(C320)  a543:-ev5az*drcq3+coe*d5q3$
(C321)  ap2[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C322)  a144:q4*d1q4+ev1$
(C323)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C324)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C325)  ap2[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C326)  a145:q4*d1q5$
(C327)  a445:ev4az*drcq5+coe1*d4q5$
(C328)  a545:-ev5az*drcq5+coe*d5q5$
(C329)  ap2[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C330)  rctt:rc*tt$
(C331)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C332)  rt:rc*dttq1+tt*drcq1$
(C333)  a151:2*coe*d1q1$
(C334)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C335)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C336)  ap2[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C337)  rt:rc*dttq2+tt*drcq2$
(C338)  a152:coe*d1q2-d1q1*q2$
(C339)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C340)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C341)  ap2[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C342)  rt:rc*dttq3+tt*drcq3$
(C343)  a153:coe*d1q3-d1q1*q3$
(C344)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C345)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C346)  ap2[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C347)  rt:rc*dttq4+tt*drcq4$
(C348)  a154:coe*d1q4-d1q1*q4$
(C349)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C350)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C351)  ap2[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C352)  rt:tt*drcq5$
(C353)  a155:coe*d1q5$
(C354)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
```

```
(C355)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C356)  ap2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C357)  diff:ap1.m-m.ap2$
(C358)  diff:ratexpand(diff);
```

```
                                    [ 0   0   0   0   0 ]
                                    [                   ]
                                    [ 0   0   0   0   0 ]
                                    [                   ]
(D358)                              [ 0   0   0   0   0 ]
                                    [                   ]
                                    [ 0   0   0   0   0 ]
                                    [                   ]
                                    [ 0   0   0   0   0 ]
```

```
(C359)  closefile(Apsup)$
```

```
(C3)  ap1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4)  ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5)  m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C6)  diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C7)  sign:1$
(C8)  cgg1:(gam-1)/gam$
(C9)  cgg2:1/(2*gam)$
(C10)  xiy:0.0$
(C11)  xiz:0.0$
(C12)  sada:sqrt(xix**2+xiy**2+xiz**2)$
(C13)  axt:xix/sada$
(C14)  ayt:xiy/sada$
(C15)  azt:xiz/sada$
(C16)  rqrq:q2**2+q3**2+q4**2$
(C17)  q6:1/q1$
(C18)  pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C19)  prgam:pr*gam$
(C20)  pp:q5+pr$
(C21)  c:sqrt(prgam*q6)$
(C22)  tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C23)  rc:q1*c$
(C24)  csad:c*sada$
(C25)  e1:tt*sada$
(C26)  e4:e1+csad$
(C27)  e5:e1-csad$
(C28)  ev1:0.5*(e1+sign*abs(e1))$
(C29)  ev4:0.5*(e4+sign*abs(e4))$
(C30)  ev5:0.0$
(C31)  cg1:cgg1$
(C32)  cg2:cgg2$
(C33)  cg3:0.0$
(C34)  d1q1:-ev1*q6$
(C35)  d1q2:xix*q6$
(C36)  d1q3:xiy*q6$
(C37)  d1q4:xiz*q6$
(C38)  d1q5:0.0$
(C39)  coe:gam*(gam-1)/(2*rc)$
(C40)  gm1q6:(gam-1)*q6$
(C41)  drcq1:coe*q5$
(C42)  drcq2:-coe*q2$
(C43)  drcq3:-coe*q3$
(C44)  drcq4:-coe*q4$
(C45)  drcq5:coe*q1$
(C46)  dcq1:(drcq1-c)*q6$
(C47)  dcq2:drcq2*q6$
(C48)  dcq3:drcq3*q6$
(C49)  dcq4:drcq4*q6$
```

```
(C50)   dcq5:drcq5*q6$
(C51)   depq1:0.5*gm1q6*rqrq*q6$
(C52)   depq2:-q2*gm1q6$
(C53)   depq3:-q3*gm1q6$
(C54)   depq4:-q4*gm1q6$
(C55)   depq5:gam$
(C56)   dttq1:-tt*q6$
(C57)   dttq2:axt*q6$
(C58)   dttq3:ayt*q6$
(C59)   dttq4:azt*q6$
(C60)   dttq5:0.0$
(C61)   d4q1:sada*(dttq1+dcq1)$
(C62)   d4q2:sada*(dttq2+dcq2)$
(C63)   d4q3:sada*(dttq3+dcq3)$
(C64)   d4q4:sada*(dttq4+dcq4)$
(C65)   d4q5:sada*dcq5$
(C66)   d5q1:sada*(dttq1-dcq1)$
(C67)   d5q2:sada*(dttq2-dcq2)$
(C68)   d5q3:sada*(dttq3-dcq3)$
(C69)   d5q4:sada*(dttq4-dcq4)$
(C70)   d5q5:-d4q5$
(C71)   a411:ev4+q1*d4q1$
(C72)   a511:ev5+q1*d5q1$
(C73)   ap1[1,1]:cg2*a411+cg3*a511$
(C74)   ap1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C75)   ap1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C76)   ap1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C77)   ap1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C78)   rcaxt:rc*axt$
(C79)   ev4ax:ev4*axt$
(C80)   ev5ax:ev5*axt$
(C81)   coe1:q2+rcaxt$
(C82)   coe:q2-rcaxt$
(C83)   a121:q2*d1q1$
(C84)   a421:ev4ax*drcq1+coe1*d4q1$
(C85)   a521:-ev5ax*drcq1+coe*d5q1$
(C86)   ap1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C87)   a122:q2*d1q2+ev1$
(C88)   a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C89)   a522:ev5-ev5ax*drcq2+coe*d5q2$
(C90)   ap1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C91)   a123:q2*d1q3$
(C92)   a423:ev4ax*drcq3+coe1*d4q3$
(C93)   a523:-ev5ax*drcq3+coe*d5q3$
(C94)   ap1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C95)   a124:q2*d1q4$
(C96)   a424:ev4ax*drcq4+coe1*d4q4$
(C97)   a524:-ev5ax*drcq4+coe*d5q4$
(C98)   ap1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C99)   a125:q2*d1q5$
(C100)  a425:ev4ax*drcq5+coe1*d4q5$
```

```
(C101)  a525:-ev5ax*drcq5+coe*d5q5$
(C102)  ap1[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C103)  rcayt:rc*ayt$
(C104)  ev4ay:ev4*ayt$
(C105)  ev5ay:ev5*ayt$
(C106)  coe1:q3+rcayt$
(C107)  coe:q3-rcayt$
(C108)  a131:q3*d1q1$
(C109)  a431:ev4ay*drcq1+coe1*d4q1$
(C110)  a531:-ev5ay*drcq1+coe*d5q1$
(C111)  ap1[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C112)  a132:q3*d1q2$
(C113)  a432:ev4ay*drcq2+coe1*d4q2$
(C114)  a532:-ev5ay*drcq2+coe*d5q2$
(C115)  ap1[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C116)  a133:q3*d1q3+ev1$
(C117)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C118)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C119)  ap1[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C120)  a134:q3*d1q4$
(C121)  a434:ev4ay*drcq4+coe1*d4q4$
(C122)  a534:-ev5ay*drcq4+coe*d5q4$
(C123)  ap1[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C124)  a135:q3*d1q5$
(C125)  a435:ev4ay*drcq5+coe1*d4q5$
(C126)  a535:-ev5ay*drcq5+coe*d5q5$
(C127)  ap1[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C128)  rcazt:rc*azt$
(C129)  ev4az:ev4*azt$
(C130)  ev5az:ev5*azt$
(C131)  coe1:q4+rcazt$
(C132)  coe:q4-rcazt$
(C133)  a141:q4*d1q1$
(C134)  a441:ev4az*drcq1+coe1*d4q1$
(C135)  a541:-ev5az*drcq1+coe*d5q1$
(C136)  ap1[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C137)  a142:q4*d1q2$
(C138)  a442:ev4az*drcq2+coe1*d4q2$
(C139)  a542:-ev5az*drcq2+coe*d5q2$
(C140)  ap1[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C141)  a143:q4*d1q3$
(C142)  a443:ev4az*drcq3+coe1*d4q3$
(C143)  a543:-ev5az*drcq3+coe*d5q3$
(C144)  ap1[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C145)  a144:q4*d1q4+ev1$
(C146)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C147)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C148)  ap1[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C149)  a145:q4*d1q5$
(C150)  a445:ev4az*drcq5+coe1*d4q5$
(C151)  a545:-ev5az*drcq5+coe*d5q5$
```

```
(C152)  ap1[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C153)  rctt:rc*tt$
(C154)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C155)  rt:rc*dttq1+tt*drcq1$
(C156)  a151:2*coe*d1q1$
(C157)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C158)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C159)  ap1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C160)  rt:rc*dttq2+tt*drcq2$
(C161)  a152:coe*d1q2-d1q1*q2$
(C162)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C163)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C164)  ap1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C165)  rt:rc*dttq3+tt*drcq3$
(C166)  a153:coe*d1q3-d1q1*q3$
(C167)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C168)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C169)  ap1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C170)  rt:rc*dttq4+tt*drcq4$
(C171)  a154:coe*d1q4-d1q1*q4$
(C172)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C173)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C174)  ap1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C175)  rt:tt*drcq5$
(C176)  a155:coe*d1q5$
(C177)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C178)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C179)  ap1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C180)  q1:q1$
(C181)  q2:q2$
(C182)  q3:q3$
(C183)  q4:-q4$
(C184)  q5:q5$
(C185)  sign:1$
(C186)  cgg1:(gam-1)/gam$
(C187)  cgg2:1/(2*gam)$
(C188)  sada:sqrt(xix**2+xiy**2+xiz**2)$
(C189)  axt:xix/sada$
(C190)  ayt:xiy/sada$
(C191)  azt:xiz/sada$
(C192)  rqrq:q2**2+q3**2+q4**2$
(C193)  q6:1/q1$
(C194)  pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195)  prgam:pr*gam$
(C196)  pp:q5+pr$
(C197)  c:sqrt(prgam*q6)$
(C198)  tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199)  rc:q1*c$
(C200)  csad:c*sada$
(C201)  e1:tt*sada$
(C202)  e4:e1+csad$
```

```
(C203)  e5:e1-csad$
(C204)  ev1:0.5*(e1+sign*abs(e1))$
(C205)  ev4:0.5*(e4+sign*abs(e4))$
(C206)  ev5:0.0$
(C207)  cg1:cgg1$
(C208)  cg2:cgg2$
(C209)  cg3:0.0$
(C210)  d1q1:-ev1*q6$
(C211)  d1q2:xix*q6$
(C212)  d1q3:xiy*q6$
(C213)  d1q4:xiz*q6$
(C214)  d1q5:0.0$
(C215)  coe:gam*(gam-1)/(2*rc)$
(C216)  gm1q6:(gam-1)*q6$
(C217)  drcq1:coe*q5$
(C218)  drcq2:-coe*q2$
(C219)  drcq3:-coe*q3$
(C220)  drcq4:-coe*q4$
(C221)  drcq5:coe*q1$
(C222)  dcq1:(drcq1-c)*q6$
(C223)  dcq2:drcq2*q6$
(C224)  dcq3:drcq3*q6$
(C225)  dcq4:drcq4*q6$
(C226)  dcq5:drcq5*q6$
(C227)  depq1:0.5*gm1q6*rqrq*q6$
(C228)  depq2:-q2*gm1q6$
(C229)  depq3:-q3*gm1q6$
(C230)  depq4:-q4*gm1q6$
(C231)  depq5:gam$
(C232)  dttq1:-tt*q6$
(C233)  dttq2:axt*q6$
(C234)  dttq3:ayt*q6$
(C235)  dttq4:azt*q6$
(C236)  dttq5:0.0$
(C237)  d4q1:sada*(dttq1+dcq1)$
(C238)  d4q2:sada*(dttq2+dcq2)$
(C239)  d4q3:sada*(dttq3+dcq3)$
(C240)  d4q4:sada*(dttq4+dcq4)$
(C241)  d4q5:sada*dcq5$
(C242)  d5q1:sada*(dttq1-dcq1)$
(C243)  d5q2:sada*(dttq2-dcq2)$
(C244)  d5q3:sada*(dttq3-dcq3)$
(C245)  d5q4:sada*(dttq4-dcq4)$
(C246)  d5q5:-d4q5$
(C247)  a411:ev4+q1*d4q1$
(C248)  a511:ev5+q1*d5q1$
(C249)  ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C250)  ap2[1,1]:cg2*a411+cg3*a511$
(C251)  ap2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C252)  ap2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
```

```
(C253)  ap2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C254)  ap2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C255)  rcaxt:rc*axt$
(C256)  ev4ax:ev4*axt$
(C257)  ev5ax:ev5*axt$
(C258)  coe1:q2+rcaxt$
(C259)  coe:q2-rcaxt$
(C260)  a121:q2*d1q1$
(C261)  a421:ev4ax*drcq1+coe1*d4q1$
(C262)  a521:-ev5ax*drcq1+coe*d5q1$
(C263)  ap2[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C264)  a122:q2*d1q2+ev1$
(C265)  a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C266)  a522:ev5-ev5ax*drcq2+coe*d5q2$
(C267)  ap2[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C268)  a123:q2*d1q3$
(C269)  a423:ev4ax*drcq3+coe1*d4q3$
(C270)  a523:-ev5ax*drcq3+coe*d5q3$
(C271)  ap2[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C272)  a124:q2*d1q4$
(C273)  a424:ev4ax*drcq4+coe1*d4q4$
(C274)  a524:-ev5ax*drcq4+coe*d5q4$
(C275)  ap2[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C276)  a125:q2*d1q5$
(C277)  a425:ev4ax*drcq5+coe1*d4q5$
(C278)  a525:-ev5ax*drcq5+coe*d5q5$
(C279)  ap2[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C280)  rcayt:rc*ayt$
(C281)  ev4ay:ev4*ayt$
(C282)  ev5ay:ev5*ayt$
(C283)  coe1:q3+rcayt$
(C284)  coe:q3-rcayt$
(C285)  a131:q3*d1q1$
(C286)  a431:ev4ay*drcq1+coe1*d4q1$
(C287)  a531:-ev5ay*drcq1+coe*d5q1$
(C288)  ap2[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C289)  a132:q3*d1q2$
(C290)  a432:ev4ay*drcq2+coe1*d4q2$
(C291)  a532:-ev5ay*drcq2+coe*d5q2$
(C292)  ap2[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C293)  a133:q3*d1q3+ev1$
(C294)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C295)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C296)  ap2[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C297)  a134:q3*d1q4$
(C298)  a434:ev4ay*drcq4+coe1*d4q4$
(C299)  a534:-ev5ay*drcq4+coe*d5q4$
(C300)  ap2[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C301)  a135:q3*d1q5$
(C302)  a435:ev4ay*drcq5+coe1*d4q5$
(C303)  a535:-ev5ay*drcq5+coe*d5q5$
```

```
(C304)  ap2[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C305)  rcazt:rc*azt$
(C306)  ev4az:ev4*azt$
(C307)  ev5az:ev5*azt$
(C308)  coe1:q4+rcazt$
(C309)  coe:q4-rcazt$
(C310)  a141:q4*d1q1$
(C311)  a441:ev4az*drcq1+coe1*d4q1$
(C312)  a541:-ev5az*drcq1+coe*d5q1$
(C313)  ap2[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C314)  a142:q4*d1q2$
(C315)  a442:ev4az*drcq2+coe1*d4q2$
(C316)  a542:-ev5az*drcq2+coe*d5q2$
(C317)  ap2[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C318)  a143:q4*d1q3$
(C319)  a443:ev4az*drcq3+coe1*d4q3$
(C320)  a543:-ev5az*drcq3+coe*d5q3$
(C321)  ap2[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C322)  a144:q4*d1q4+ev1$
(C323)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C324)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C325)  ap2[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C326)  a145:q4*d1q5$
(C327)  a445:ev4az*drcq5+coe1*d4q5$
(C328)  a545:-ev5az*drcq5+coe*d5q5$
(C329)  ap2[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C330)  rctt:rc*tt$
(C331)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C332)  rt:rc*dttq1+tt*drcq1$
(C333)  a151:2*coe*d1q1$
(C334)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C335)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C336)  ap2[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C337)  rt:rc*dttq2+tt*drcq2$
(C338)  a152:coe*d1q2-d1q1*q2$
(C339)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C340)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C341)  ap2[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C342)  rt:rc*dttq3+tt*drcq3$
(C343)  a153:coe*d1q3-d1q1*q3$
(C344)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C345)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C346)  ap2[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C347)  rt:rc*dttq4+tt*drcq4$
(C348)  a154:coe*d1q4-d1q1*q4$
(C349)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C350)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C351)  ap2[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C352)  rt:tt*drcq5$
(C353)  a155:coe*d1q5$
(C354)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
```

```
(C355)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C356)  ap2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C357)  diff:ap1.m-m.ap2$
(C358)  diff:ratexpand(diff);
```

$$
(D358) \quad
\begin{bmatrix}
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0
\end{bmatrix}
$$

```
(C359)  closefile(Apsub)$
```

```
(C3)  ap1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4)  ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5)  m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C6)  diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C7)  sign:1$
(C8)  cgg1:(gam-1)/gam$
(C9)  cgg2:1/(2*gam)$
(C10) xiy:0.0$
(C11) xiz:0.0$
(C12) sada:sqrt(xix**2+xiy**2+xiz**2)$
(C13) axt:xix/sada$
(C14) ayt:xiy/sada$
(C15) azt:xiz/sada$
(C16) rqrq:q2**2+q3**2+q4**2$
(C17) q6:1/q1$
(C18) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C19) prgam:pr*gam$
(C20) pp:q5+pr$
(C21) c:sqrt(prgam*q6)$
(C22) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C23) rc:q1*c$
(C24) csad:c*sada$
(C25) e1:tt*sada$
(C26) e4:e1+csad$
(C27) e5:e1-csad$
(C28) ev1:0.5*(e1+sign*abs(e1))$
(C29) ev4:0.5*(e4+sign*abs(e4))$
(C30) ev5:0.0$
(C31) cg1:cgg1$
(C32) cg2:cgg2$
(C33) cg3:0.0$
(C34) d1q1:-ev1*q6$
(C35) d1q2:xix*q6$
(C36) d1q3:xiy*q6$
(C37) d1q4:xiz*q6$
(C38) d1q5:0.0$
(C39) coe:gam*(gam-1)/(2*rc)$
(C40) gm1q6:(gam-1)*q6$
(C41) drcq1:coe*q5$
(C42) drcq2:-coe*q2$
(C43) drcq3:-coe*q3$
(C44) drcq4:-coe*q4$
(C45) drcq5:coe*q1$
(C46) dcq1:(drcq1-c)*q6$
(C47) dcq2:drcq2*q6$
(C48) dcq3:drcq3*q6$
(C49) dcq4:drcq4*q6$
```

```
(C50)  dcq5:drcq5*q6$
(C51)  depq1:0.5*gm1q6*rqrq*q6$
(C52)  depq2:-q2*gm1q6$
(C53)  depq3:-q3*gm1q6$
(C54)  depq4:-q4*gm1q6$
(C55)  depq5:gam$
(C56)  dttq1:-tt*q6$
(C57)  dttq2:axt*q6$
(C58)  dttq3:ayt*q6$
(C59)  dttq4:azt*q6$
(C60)  dttq5:0.0$
(C61)  d4q1:sada*(dttq1+dcq1)$
(C62)  d4q2:sada*(dttq2+dcq2)$
(C63)  d4q3:sada*(dttq3+dcq3)$
(C64)  d4q4:sada*(dttq4+dcq4)$
(C65)  d4q5:sada*dcq5$
(C66)  d5q1:sada*(dttq1-dcq1)$
(C67)  d5q2:sada*(dttq2-dcq2)$
(C68)  d5q3:sada*(dttq3-dcq3)$
(C69)  d5q4:sada*(dttq4-dcq4)$
(C70)  d5q5:-d4q5$
(C71)  a411:ev4+q1*d4q1$
(C72)  a511:ev5+q1*d5q1$
(C73)  ap1[1,1]:cg2*a411+cg3*a511$
(C74)  ap1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C75)  ap1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C76)  ap1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C77)  ap1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C78)  rcaxt:rc*axt$
(C79)  ev4ax:ev4*axt$
(C80)  ev5ax:ev5*axt$
(C81)  coe1:q2+rcaxt$
(C82)  coe:q2-rcaxt$
(C83)  a121:q2*d1q1$
(C84)  a421:ev4ax*drcq1+coe1*d4q1$
(C85)  a521:-ev5ax*drcq1+coe*d5q1$
(C86)  ap1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C87)  a122:q2*d1q2+ev1$
(C88)  a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C89)  a522:ev5-ev5ax*drcq2+coe*d5q2$
(C90)  ap1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C91)  a123:q2*d1q3$
(C92)  a423:ev4ax*drcq3+coe1*d4q3$
(C93)  a523:-ev5ax*drcq3+coe*d5q3$
(C94)  ap1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C95)  a124:q2*d1q4$
(C96)  a424:ev4ax*drcq4+coe1*d4q4$
(C97)  a524:-ev5ax*drcq4+coe*d5q4$
(C98)  ap1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C99)  a125:q2*d1q5$
(C100) a425:ev4ax*drcq5+coe1*d4q5$
```

```
(C101)  a525:-ev5ax*drcq5+coe*d5q5$
(C102)  ap1[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C103)  rcayt:rc*ayt$
(C104)  ev4ay:ev4*ayt$
(C105)  ev5ay:ev5*ayt$
(C106)  coe1:q3+rcayt$
(C107)  coe:q3-rcayt$
(C108)  a131:q3*d1q1$
(C109)  a431:ev4ay*drcq1+coe1*d4q1$
(C110)  a531:-ev5ay*drcq1+coe*d5q1$
(C111)  ap1[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C112)  a132:q3*d1q2$
(C113)  a432:ev4ay*drcq2+coe1*d4q2$
(C114)  a532:-ev5ay*drcq2+coe*d5q2$
(C115)  ap1[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C116)  a133:q3*d1q3+ev1$
(C117)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C118)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C119)  ap1[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C120)  a134:q3*d1q4$
(C121)  a434:ev4ay*drcq4+coe1*d4q4$
(C122)  a534:-ev5ay*drcq4+coe*d5q4$
(C123)  ap1[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C124)  a135:q3*d1q5$
(C125)  a435:ev4ay*drcq5+coe1*d4q5$
(C126)  a535:-ev5ay*drcq5+coe*d5q5$
(C127)  ap1[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C128)  rcazt:rc*azt$
(C129)  ev4az:ev4*azt$
(C130)  ev5az:ev5*azt$
(C131)  coe1:q4+rcazt$
(C132)  coe:q4-rcazt$
(C133)  a141:q4*d1q1$
(C134)  a441:ev4az*drcq1+coe1*d4q1$
(C135)  a541:-ev5az*drcq1+coe*d5q1$
(C136)  ap1[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C137)  a142:q4*d1q2$
(C138)  a442:ev4az*drcq2+coe1*d4q2$
(C139)  a542:-ev5az*drcq2+coe*d5q2$
(C140)  ap1[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C141)  a143:q4*d1q3$
(C142)  a443:ev4az*drcq3+coe1*d4q3$
(C143)  a543:-ev5az*drcq3+coe*d5q3$
(C144)  ap1[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C145)  a144:q4*d1q4+ev1$
(C146)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C147)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C148)  ap1[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C149)  a145:q4*d1q5$
(C150)  a445:ev4az*drcq5+coe1*d4q5$
(C151)  a545:-ev5az*drcq5+coe*d5q5$
```

```
(C152)   ap1[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C153)   rctt:rc*tt$
(C154)   coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C155)   rt:rc*dttq1+tt*drcq1$
(C156)   a151:2*coe*d1q1$
(C157)   a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C158)   a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C159)   ap1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C160)   rt:rc*dttq2+tt*drcq2$
(C161)   a152:coe*d1q2-d1q1*q2$
(C162)   a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C163)   a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C164)   ap1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C165)   rt:rc*dttq3+tt*drcq3$
(C166)   a153:coe*d1q3-d1q1*q3$
(C167)   a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C168)   a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C169)   ap1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C170)   rt:rc*dttq4+tt*drcq4$
(C171)   a154:coe*d1q4-d1q1*q4$
(C172)   a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C173)   a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C174)   ap1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C175)   rt:tt*drcq5$
(C176)   a155:coe*d1q5$
(C177)   a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C178)   a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C179)   ap1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C180)   q1:q1$
(C181)   q2:q2$
(C182)   q3:q3$
(C183)   q4:-q4$
(C184)   q5:q5$
(C185)   sign:1$
(C186)   cgg1:(gam-1)/gam$
(C187)   cgg2:1/(2*gam)$
(C188)   sada:sqrt(xix**2+xiy**2+xiz**2)$
(C189)   axt:xix/sada$
(C190)   ayt:xiy/sada$
(C191)   azt:xiz/sada$
(C192)   rqrq:q2**2+q3**2+q4**2$
(C193)   q6:1/q1$
(C194)   pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195)   prgam:pr*gam$
(C196)   pp:q5+pr$
(C197)   c:sqrt(prgam*q6)$
(C198)   tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199)   rc:q1*c$
(C200)   csad:c*sada$
(C201)   e1:tt*sada$
(C202)   e4:e1+csad$
```

```
(C203)  e5:e1-csad$
(C204)  ev1:0.5*(e1+sign*abs(e1))$
(C205)  ev4:0.5*(e4+sign*abs(e4))$
(C206)  ev5:0.0$
(C207)  cg1:cgg1$
(C208)  cg2:cgg2$
(C209)  cg3:0.0$
(C210)  d1q1:-ev1*q6$
(C211)  d1q2:xix*q6$
(C212)  d1q3:xiy*q6$
(C213)  d1q4:xiz*q6$
(C214)  d1q5:0.0$
(C215)  coe:gam*(gam-1)/(2*rc)$
(C216)  gm1q6:(gam-1)*q6$
(C217)  drcq1:coe*q5$
(C218)  drcq2:-coe*q2$
(C219)  drcq3:-coe*q3$
(C220)  drcq4:-coe*q4$
(C221)  drcq5:coe*q1$
(C222)  dcq1:(drcq1-c)*q6$
(C223)  dcq2:drcq2*q6$
(C224)  dcq3:drcq3*q6$
(C225)  dcq4:drcq4*q6$
(C226)  dcq5:drcq5*q6$
(C227)  depq1:0.5*gm1q6*rqrq*q6$
(C228)  depq2:-q2*gm1q6$
(C229)  depq3:-q3*gm1q6$
(C230)  depq4:-q4*gm1q6$
(C231)  depq5:gam$
(C232)  dttq1:-tt*q6$
(C233)  dttq2:axt*q6$
(C234)  dttq3:ayt*q6$
(C235)  dttq4:azt*q6$
(C236)  dttq5:0.0$
(C237)  d4q1:sada*(dttq1+dcq1)$
(C238)  d4q2:sada*(dttq2+dcq2)$
(C239)  d4q3:sada*(dttq3+dcq3)$
(C240)  d4q4:sada*(dttq4+dcq4)$
(C241)  d4q5:sada*dcq5$
(C242)  d5q1:sada*(dttq1-dcq1)$
(C243)  d5q2:sada*(dttq2-dcq2)$
(C244)  d5q3:sada*(dttq3-dcq3)$
(C245)  d5q4:sada*(dttq4-dcq4)$
(C246)  d5q5:-d4q5$
(C247)  a411:ev4+q1*d4q1$
(C248)  a511:ev5+q1*d5q1$
(C249)  ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C250)  ap2[1,1]:cg2*a411+cg3*a511$
(C251)  ap2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C252)  ap2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
```

```
(C253)  ap2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C254)  ap2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C255)  rcaxt:rc*axt$
(C256)  ev4ax:ev4*axt$
(C257)  ev5ax:ev5*axt$
(C258)  coe1:q2+rcaxt$
(C259)  coe:q2-rcaxt$
(C260)  a121:q2*d1q1$
(C261)  a421:ev4ax*drcq1+coe1*d4q1$
(C262)  a521:-ev5ax*drcq1+coe*d5q1$
(C263)  ap2[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C264)  a122:q2*d1q2+ev1$
(C265)  a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C266)  a522:ev5-ev5ax*drcq2+coe*d5q2$
(C267)  ap2[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C268)  a123:q2*d1q3$
(C269)  a423:ev4ax*drcq3+coe1*d4q3$
(C270)  a523:-ev5ax*drcq3+coe*d5q3$
(C271)  ap2[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C272)  a124:q2*d1q4$
(C273)  a424:ev4ax*drcq4+coe1*d4q4$
(C274)  a524:-ev5ax*drcq4+coe*d5q4$
(C275)  ap2[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C276)  a125:q2*d1q5$
(C277)  a425:ev4ax*drcq5+coe1*d4q5$
(C278)  a525:-ev5ax*drcq5+coe*d5q5$
(C279)  ap2[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C280)  rcayt:rc*ayt$
(C281)  ev4ay:ev4*ayt$
(C282)  ev5ay:ev5*ayt$
(C283)  coe1:q3+rcayt$
(C284)  coe:q3-rcayt$
(C285)  a131:q3*d1q1$
(C286)  a431:ev4ay*drcq1+coe1*d4q1$
(C287)  a531:-ev5ay*drcq1+coe*d5q1$
(C288)  ap2[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C289)  a132:q3*d1q2$
(C290)  a432:ev4ay*drcq2+coe1*d4q2$
(C291)  a532:-ev5ay*drcq2+coe*d5q2$
(C292)  ap2[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C293)  a133:q3*d1q3+ev1$
(C294)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C295)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C296)  ap2[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C297)  a134:q3*d1q4$
(C298)  a434:ev4ay*drcq4+coe1*d4q4$
(C299)  a534:-ev5ay*drcq4+coe*d5q4$
(C300)  ap2[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C301)  a135:q3*d1q5$
(C302)  a435:ev4ay*drcq5+coe1*d4q5$
(C303)  a535:-ev5ay*drcq5+coe*d5q5$
```

```
(C304)  ap2[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C305)  rcazt:rc*azt$
(C306)  ev4az:ev4*azt$
(C307)  ev5az:ev5*azt$
(C308)  coe1:q4+rcazt$
(C309)  coe:q4-rcazt$
(C310)  a141:q4*d1q1$
(C311)  a441:ev4az*drcq1+coe1*d4q1$
(C312)  a541:-ev5az*drcq1+coe*d5q1$
(C313)  ap2[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C314)  a142:q4*d1q2$
(C315)  a442:ev4az*drcq2+coe1*d4q2$
(C316)  a542:-ev5az*drcq2+coe*d5q2$
(C317)  ap2[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C318)  a143:q4*d1q3$
(C319)  a443:ev4az*drcq3+coe1*d4q3$
(C320)  a543:-ev5az*drcq3+coe*d5q3$
(C321)  ap2[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C322)  a144:q4*d1q4+ev1$
(C323)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C324)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C325)  ap2[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C326)  a145:q4*d1q5$
(C327)  a445:ev4az*drcq5+coe1*d4q5$
(C328)  a545:-ev5az*drcq5+coe*d5q5$
(C329)  ap2[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C330)  rctt:rc*tt$
(C331)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C332)  rt:rc*dttq1+tt*drcq1$
(C333)  a151:2*coe*d1q1$
(C334)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C335)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C336)  ap2[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C337)  rt:rc*dttq2+tt*drcq2$
(C338)  a152:coe*d1q2-d1q1*q2$
(C339)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C340)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C341)  ap2[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C342)  rt:rc*dttq3+tt*drcq3$
(C343)  a153:coe*d1q3-d1q1*q3$
(C344)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C345)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C346)  ap2[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C347)  rt:rc*dttq4+tt*drcq4$
(C348)  a154:coe*d1q4-d1q1*q4$
(C349)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C350)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C351)  ap2[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C352)  rt:tt*drcq5$
(C353)  a155:coe*d1q5$
(C354)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
```

```
(C355)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C356)  ap2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C357)  diff:ap1.m-m.ap2$
(C358)  diff:ratexpand(diff);
```

$$
(D358) \quad
\begin{bmatrix}
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0
\end{bmatrix}
$$

```
(C359)  closefile(Apsub)$
```

```
(C3)  am1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4)  am2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5)  m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C6)  sign:-1$
(C7)  cgg1:(gam-1)/gam$
(C8)  cgg2:1/(2*gam)$
(C9)  xiy:0.0$
(C10) xiz:0.0$
(C11) sada:sqrt(xix**2+xiy**2+xiz**2)$
(C12) axt:xix/sada$
(C13) ayt:xiy/sada$
(C14) azt:xiz/sada$
(C15) rqrq:q2**2+q3**2+q4**2$
(C16) q6:1/q1$
(C17) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C18) prgam:pr*gam$
(C19) pp:q5+pr$
(C20) c:sqrt(prgam*q6)$
(C21) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C22) rc:q1*c$
(C23) csad:c*sada$
(C24) e1:tt*sada$
(C25) e4:e1+csad$
(C26) e5:e1-csad$
(C27) ev1:0.0$
(C28) ev4:0.0$
(C29) ev5:0.0$
(C30) cg1:0.0$
(C31) cg2:0.0$
(C32) cg3:0.0$
(C33) d1q1:-ev1*q6$
(C34) d1q2:xix*q6$
(C35) d1q3:xiy*q6$
(C36) d1q4:xiz*q6$
(C37) d1q5:0.0$
(C38) coe:gam*(gam-1)/(2*rc)$
(C39) gm1q6:(gam-1)*q6$
(C40) drcq1:coe*q5$
(C41) drcq2:-coe*q2$
(C42) drcq3:-coe*q3$
(C43) drcq4:-coe*q4$
(C44) drcq5:coe*q1$
(C45) dcq1:(drcq1-c)*q6$
(C46) dcq2:drcq2*q6$
(C47) dcq3:drcq3*q6$
(C48) dcq4:drcq4*q6$
(C49) dcq5:drcq5*q6$
(C50) depq1:0.5*gm1q6*rqrq*q6$
```

```
(C51)    depq2:-q2*gm1q6$
(C52)    depq3:-q3*gm1q6$
(C53)    depq4:-q4*gm1q6$
(C54)    depq5:gam$
(C55)    dttq1:-tt*q6$
(C56)    dttq2:axt*q6$
(C57)    dttq3:ayt*q6$
(C58)    dttq4:azt*q6$
(C59)    dttq5:0.0$
(C60)    d4q1:sada*(dttq1+dcq1)$
(C61)    d4q2:sada*(dttq2+dcq2)$
(C62)    d4q3:sada*(dttq3+dcq3)$
(C63)    d4q4:sada*(dttq4+dcq4)$
(C64)    d4q5:sada*dcq5$
(C65)    d5q1:sada*(dttq1-dcq1)$
(C66)    d5q2:sada*(dttq2-dcq2)$
(C67)    d5q3:sada*(dttq3-dcq3)$
(C68)    d5q4:sada*(dttq4-dcq4)$
(C69)    d5q5:-d4q5$
(C70)    a411:ev4+q1*d4q1$
(C71)    a511:ev5+q1*d5q1$
(C72)    am1[1,1]:cg2*a411+cg3*a511$
(C73)    am1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C74)    am1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C75)    am1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C76)    am1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C77)    rcaxt:rc*axt$
(C78)    ev4ax:ev4*axt$
(C79)    ev5ax:ev5*axt$
(C80)    coe1:q2+rcaxt$
(C81)    coe:q2-rcaxt$
(C82)    a121:q2*d1q1$
(C83)    a421:ev4ax*drcq1+coe1*d4q1$
(C84)    a521:-ev5ax*drcq1+coe*d5q1$
(C85)    am1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C86)    a122:q2*d1q2+ev1$
(C87)    a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C88)    a522:ev5-ev5ax*drcq2+coe*d5q2$
(C89)    am1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C90)    a123:q2*d1q3$
(C91)    a423:ev4ax*drcq3+coe1*d4q3$
(C92)    a523:-ev5ax*drcq3+coe*d5q3$
(C93)    am1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C94)    a124:q2*d1q4$
(C95)    a424:ev4ax*drcq4+coe1*d4q4$
(C96)    a524:-ev5ax*drcq4+coe*d5q4$
(C97)    am1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C98)    a125:q2*d1q5$
(C99)    a425:ev4ax*drcq5+coe1*d4q5$
(C100)   a525:-ev5ax*drcq5+coe*d5q5$
(C101)   am1[2,5]:cg1*a125+cg2*a425+cg3*a525$
```

```
(C102)  rcayt:rc*ayt$
(C103)  ev4ay:ev4*ayt$
(C104)  ev5ay:ev5*ayt$
(C105)  coe1:q3+rcayt$
(C106)  coe:q3-rcayt$
(C107)  a131:q3*d1q1$
(C108)  a431:ev4ay*drcq1+coe1*d4q1$
(C109)  a531:-ev5ay*drcq1+coe*d5q1$
(C110)  am1[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C111)  a132:q3*d1q2$
(C112)  a432:ev4ay*drcq2+coe1*d4q2$
(C113)  a532:-ev5ay*drcq2+coe*d5q2$
(C114)  am1[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C115)  a133:q3*d1q3+ev1$
(C116)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C117)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C118)  am1[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C119)  a134:q3*d1q4$
(C120)  a434:ev4ay*drcq4+coe1*d4q4$
(C121)  a534:-ev5ay*drcq4+coe*d5q4$
(C122)  am1[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C123)  a135:q3*d1q5$
(C124)  a435:ev4ay*drcq5+coe1*d4q5$
(C125)  a535:-ev5ay*drcq5+coe*d5q5$
(C126)  am1[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C127)  rcazt:rc*azt$
(C128)  ev4az:ev4*azt$
(C129)  ev5az:ev5*azt$
(C130)  coe1:q4+rcazt$
(C131)  coe:q4-rcazt$
(C132)  a141:q4*d1q1$
(C133)  a441:ev4az*drcq1+coe1*d4q1$
(C134)  a541:-ev5az*drcq1+coe*d5q1$
(C135)  am1[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C136)  a142:q4*d1q2$
(C137)  a442:ev4az*drcq2+coe1*d4q2$
(C138)  a542:-ev5az*drcq2+coe*d5q2$
(C139)  am1[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C140)  a143:q4*d1q3$
(C141)  a443:ev4az*drcq3+coe1*d4q3$
(C142)  a543:-ev5az*drcq3+coe*d5q3$
(C143)  am1[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C144)  a144:q4*d1q4+ev1$
(C145)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C146)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C147)  am1[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C148)  a145:q4*d1q5$
(C149)  a445:ev4az*drcq5+coe1*d4q5$
(C150)  a545:-ev5az*drcq5+coe*d5q5$
(C151)  am1[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C152)  rctt:rc*tt$
```

```
(C153)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C154)  rt:rc*dttq1+tt*drcq1$
(C155)  a151:2*coe*d1q1$
(C156)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C157)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C158)  am1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C159)  rt:rc*dttq2+tt*drcq2$
(C160)  a152:coe*d1q2-d1q1*q2$
(C161)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C162)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C163)  am1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C164)  rt:rc*dttq3+tt*drcq3$
(C165)  a153:coe*d1q3-d1q1*q3$
(C166)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C167)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C168)  am1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C169)  rt:rc*dttq4+tt*drcq4$
(C170)  a154:coe*d1q4-d1q1*q4$
(C171)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C172)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C173)  am1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C174)  rt:tt*drcq5$
(C175)  a155:coe*d1q5$
(C176)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C177)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C178)  am1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C179)  q1:q1$
(C180)  q2:q2$
(C181)  q3:q3$
(C182)  q4:-q4$
(C183)  q5:q5$
(C184)  sign:1$
(C185)  cgg1:(gam-1)/gam$
(C186)  cgg2:1/(2*gam)$
(C187)  sada:sqrt(xix**2+xiy**2+xiz**2)$
(C188)  axt:xix/sada$
(C189)  ayt:xiy/sada$
(C190)  azt:xiz/sada$
(C191)  rqrq:q2**2+q3**2+q4**2$
(C192)  q6:1/q1$
(C193)  pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C194)  prgam:pr*gam$
(C195)  pp:q5+pr$
(C196)  c:sqrt(prgam*q6)$
(C197)  tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C198)  rc:q1*c$
(C199)  csad:c*sada$
(C200)  e1:tt*sada$
(C201)  e4:e1+csad$
(C202)  e5:e1-csad$
(C203)  ev1:0.0$
```

```
(C204)  ev4:0.0$
(C205)  ev5:0.0$
(C206)  cg1:0.0$
(C207)  cg2:0.0$
(C208)  cg3:0.0$
(C209)  d1q1:-ev1*q6$
(C210)  d1q2:xix*q6$
(C211)  d1q3:xiy*q6$
(C212)  d1q4:xiz*q6$
(C213)  d1q5:0.0$
(C214)  coe:gam*(gam-1)/(2*rc)$
(C215)  gm1q6:(gam-1)*q6$
(C216)  drcq1:coe*q5$
(C217)  drcq2:-coe*q2$
(C218)  drcq3:-coe*q3$
(C219)  drcq4:-coe*q4$
(C220)  drcq5:coe*q1$
(C221)  dcq1:(drcq1-c)*q6$
(C222)  dcq2:drcq2*q6$
(C223)  dcq3:drcq3*q6$
(C224)  dcq4:drcq4*q6$
(C225)  dcq5:drcq5*q6$
(C226)  depq1:0.5*gm1q6*rqrq*q6$
(C227)  depq2:-q2*gm1q6$
(C228)  depq3:-q3*gm1q6$
(C229)  depq4:-q4*gm1q6$
(C230)  depq5:gam$
(C231)  dttq1:-tt*q6$
(C232)  dttq2:axt*q6$
(C233)  dttq3:ayt*q6$
(C234)  dttq4:azt*q6$
(C235)  dttq5:0.0$
(C236)  d4q1:sada*(dttq1+dcq1)$
(C237)  d4q2:sada*(dttq2+dcq2)$
(C238)  d4q3:sada*(dttq3+dcq3)$
(C239)  d4q4:sada*(dttq4+dcq4)$
(C240)  d4q5:sada*dcq5$
(C241)  d5q1:sada*(dttq1-dcq1)$
(C242)  d5q2:sada*(dttq2-dcq2)$
(C243)  d5q3:sada*(dttq3-dcq3)$
(C244)  d5q4:sada*(dttq4-dcq4)$
(C245)  d5q5:-d4q5$
(C246)  a411:ev4+q1*d4q1$
(C247)  a511:ev5+q1*d5q1$
(C248)  am2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C249)  am2[1,1]:cg2*a411+cg3*a511$
(C250)  am2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C251)  am2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C252)  am2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C253)  am2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
```

```
(C254)   rcaxt:rc*axt$
(C255)   ev4ax:ev4*axt$
(C256)   ev5ax:ev5*axt$
(C257)   coe1:q2+rcaxt$
(C258)   coe:q2-rcaxt$
(C259)   a121:q2*d1q1$
(C260)   a421:ev4ax*drcq1+coe1*d4q1$
(C261)   a521:-ev5ax*drcq1+coe*d5q1$
(C262)   am2[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C263)   a122:q2*d1q2+ev1$
(C264)   a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C265)   a522:ev5-ev5ax*drcq2+coe*d5q2$
(C266)   am2[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C267)   a123:q2*d1q3$
(C268)   a423:ev4ax*drcq3+coe1*d4q3$
(C269)   a523:-ev5ax*drcq3+coe*d5q3$
(C270)   am2[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C271)   a124:q2*d1q4$
(C272)   a424:ev4ax*drcq4+coe1*d4q4$
(C273)   a524:-ev5ax*drcq4+coe*d5q4$
(C274)   am2[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C275)   a125:q2*d1q5$
(C276)   a425:ev4ax*drcq5+coe1*d4q5$
(C277)   a525:-ev5ax*drcq5+coe*d5q5$
(C278)   am2[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C279)   rcayt:rc*ayt$
(C280)   ev4ay:ev4*ayt$
(C281)   ev5ay:ev5*ayt$
(C282)   coe1:q3+rcayt$
(C283)   coe:q3-rcayt$
(C284)   a131:q3*d1q1$
(C285)   a431:ev4ay*drcq1+coe1*d4q1$
(C286)   a531:-ev5ay*drcq1+coe*d5q1$
(C287)   am2[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C288)   a132:q3*d1q2$
(C289)   a432:ev4ay*drcq2+coe1*d4q2$
(C290)   a532:-ev5ay*drcq2+coe*d5q2$
(C291)   am2[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C292)   a133:q3*d1q3+ev1$
(C293)   a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C294)   a533:ev5-ev5ay*drcq3+coe*d5q3$
(C295)   am2[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C296)   a134:q3*d1q4$
(C297)   a434:ev4ay*drcq4+coe1*d4q4$
(C298)   a534:-ev5ay*drcq4+coe*d5q4$
(C299)   am2[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C300)   a135:q3*d1q5$
(C301)   a435:ev4ay*drcq5+coe1*d4q5$
(C302)   a535:-ev5ay*drcq5+coe*d5q5$
(C303)   am2[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C304)   rcazt:rc*azt$
```

```
(C305)  ev4az:ev4*azt$
(C306)  ev5az:ev5*azt$
(C307)  coe1:q4+rcazt$
(C308)  coe:q4-rcazt$
(C309)  a141:q4*d1q1$
(C310)  a441:ev4az*drcq1+coe1*d4q1$
(C311)  a541:-ev5az*drcq1+coe*d5q1$
(C312)  am2[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C313)  a142:q4*d1q2$
(C314)  a442:ev4az*drcq2+coe1*d4q2$
(C315)  a542:-ev5az*drcq2+coe*d5q2$
(C316)  am2[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C317)  a143:q4*d1q3$
(C318)  a443:ev4az*drcq3+coe1*d4q3$
(C319)  a543:-ev5az*drcq3+coe*d5q3$
(C320)  am2[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C321)  a144:q4*d1q4+ev1$
(C322)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C323)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C324)  am2[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C325)  a145:q4*d1q5$
(C326)  a445:ev4az*drcq5+coe1*d4q5$
(C327)  a545:-ev5az*drcq5+coe*d5q5$
(C328)  am2[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C329)  rctt:rc*tt$
(C330)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C331)  rt:rc*dttq1+tt*drcq1$
(C332)  a151:2*coe*d1q1$
(C333)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C334)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C335)  am2[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C336)  rt:rc*dttq2+tt*drcq2$
(C337)  a152:coe*d1q2-d1q1*q2$
(C338)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C339)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C340)  am2[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C341)  rt:rc*dttq3+tt*drcq3$
(C342)  a153:coe*d1q3-d1q1*q3$
(C343)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C344)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C345)  am2[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C346)  rt:rc*dttq4+tt*drcq4$
(C347)  a154:coe*d1q4-d1q1*q4$
(C348)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C349)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C350)  am2[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C351)  rt:tt*drcq5$
(C352)  a155:coe*d1q5$
(C353)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C354)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C355)  am2[5,5]:cg1*a155+cg2*a455+cg3*a555$
```

```
(C356) diff:am1.m-m.am1$
(C357) diff:ratexpand(diff);
```

$$
\begin{bmatrix}
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0
\end{bmatrix}
$$

(D357)

```
(C358) closefile(Amsup)$
```

```
(C3)  diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C4)  m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C5)  sign:1$
(C6)  cgg1:(gam-1)/gam$
(C7)  cgg2:1/(2*gam)$
(C8)  xiy:0.0$
(C9)  xiz:0.0$
(C10)  sada:sqrt(xix**2+xiy**2+xiz**2)$
(C11)  axt:xix/sada$
(C12)  ayt:xiy/sada$
(C13)  azt:xiz/sada$
(C14)  rqrq:q2**2+q3**2+q4**2$
(C15)  q6:1/q1$
(C16)  pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C17)  prgam:pr*gam$
(C18)  pp:q5+pr$
(C19)  c:sqrt(prgam*q6)$
(C20)  tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C21)  rc:q1*c$
(C22)  csad:c*sada$
(C23)  e1:tt*sada$
(C24)  e4:e1+csad$
(C25)  e5:e1-csad$
(C26)  ev1:0.0$
(C27)  ev4:0.0$
(C28)  ev5:0.5*(e5+sign*abs(e5))$
(C29)  cg1:0.0$
(C30)  cg2:0.0$
(C31)  cg3:cgg2$
(C32)  d1q1:-ev1*q6$
(C33)  d1q2:xix*q6$
(C34)  d1q3:xiy*q6$
(C35)  d1q4:xiz*q6$
(C36)  d1q5:0.0$
(C37)  coe:gam*(gam-1)/(2*rc)$
(C38)  gm1q6:(gam-1)*q6$
(C39)  drcq1:coe*q5$
(C40)  drcq2:-coe*q2$
(C41)  drcq3:-coe*q3$
(C42)  drcq4:-coe*q4$
(C43)  drcq5:coe*q1$
(C44)  dcq1:(drcq1-c)*q6$
(C45)  dcq2:drcq2*q6$
(C46)  dcq3:drcq3*q6$
(C47)  dcq4:drcq4*q6$
(C48)  dcq5:drcq5*q6$
(C49)  depq1:0.5*gm1q6*rqrq*q6$
(C50)  depq2:-q2*gm1q6$
(C51)  depq3:-q3*gm1q6$
```

```
(C52)  depq4:-q4*gm1q6$
(C53)  depq5:gam$
(C54)  dttq1:-tt*q6$
(C55)  dttq2:axt*q6$
(C56)  dttq3:ayt*q6$
(C57)  dttq4:azt*q6$
(C58)  dttq5:0.0$
(C59)  d4q1:sada*(dttq1+dcq1)$
(C60)  d4q2:sada*(dttq2+dcq2)$
(C61)  d4q3:sada*(dttq3+dcq3)$
(C62)  d4q4:sada*(dttq4+dcq4)$
(C63)  d4q5:sada*dcq5$
(C64)  d5q1:sada*(dttq1-dcq1)$
(C65)  d5q2:sada*(dttq2-dcq2)$
(C66)  d5q3:sada*(dttq3-dcq3)$
(C67)  d5q4:sada*(dttq4-dcq4)$
(C68)  d5q5:-d4q5$
(C69)  a411:ev4+q1*d4q1$
(C70)  a511:ev5+q1*d5q1$
(C71)  ap1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C72)  ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C73)  ap1[1,1]:cg2*a411+cg3*a511$
(C74)  ap1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C75)  ap1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C76)  ap1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C77)  ap1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C78)  rcaxt:rc*axt$
(C79)  ev4ax:ev4*axt$
(C80)  ev5ax:ev5*axt$
(C81)  coe1:q2+rcaxt$
(C82)  coe:q2-rcaxt$
(C83)  a121:q2*d1q1$
(C84)  a421:ev4ax*drcq1+coe1*d4q1$
(C85)  a521:-ev5ax*drcq1+coe*d5q1$
(C86)  ap1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C87)  a122:q2*d1q2+ev1$
(C88)  a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C89)  a522:ev5-ev5ax*drcq2+coe*d5q2$
(C90)  ap1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C91)  a123:q2*d1q3$
(C92)  a423:ev4ax*drcq3+coe1*d4q3$
(C93)  a523:-ev5ax*drcq3+coe*d5q3$
(C94)  ap1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C95)  a124:q2*d1q4$
(C96)  a424:ev4ax*drcq4+coe1*d4q4$
(C97)  a524:-ev5ax*drcq4+coe*d5q4$
(C98)  ap1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C99)  a125:q2*d1q5$
(C100)  a425:ev4ax*drcq5+coe1*d4q5$
```

```
(C101)  a525:-ev5ax*drcq5+coe*d5q5$
(C102)  ap1[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C103)  rcayt:rc*ayt$
(C104)  ev4ay:ev4*ayt$
(C105)  ev5ay:ev5*ayt$
(C106)  coe1:q3+rcayt$
(C107)  coe:q3-rcayt$
(C108)  a131:q3*d1q1$
(C109)  a431:ev4ay*drcq1+coe1*d4q1$
(C110)  a531:-ev5ay*drcq1+coe*d5q1$
(C111)  ap1[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C112)  a132:q3*d1q2$
(C113)  a432:ev4ay*drcq2+coe1*d4q2$
(C114)  a532:-ev5ay*drcq2+coe*d5q2$
(C115)  ap1[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C116)  a133:q3*d1q3+ev1$
(C117)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C118)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C119)  ap1[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C120)  a134:q3*d1q4$
(C121)  a434:ev4ay*drcq4+coe1*d4q4$
(C122)  a534:-ev5ay*drcq4+coe*d5q4$
(C123)  ap1[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C124)  a135:q3*d1q5$
(C125)  a435:ev4ay*drcq5+coe1*d4q5$
(C126)  a535:-ev5ay*drcq5+coe*d5q5$
(C127)  ap1[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C128)  rcazt:rc*azt$
(C129)  ev4az:ev4*azt$
(C130)  ev5az:ev5*azt$
(C131)  coe1:q4+rcazt$
(C132)  coe:q4-rcazt$
(C133)  a141:q4*d1q1$
(C134)  a441:ev4az*drcq1+coe1*d4q1$
(C135)  a541:-ev5az*drcq1+coe*d5q1$
(C136)  ap1[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C137)  a142:q4*d1q2$
(C138)  a442:ev4az*drcq2+coe1*d4q2$
(C139)  a542:-ev5az*drcq2+coe*d5q2$
(C140)  ap1[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C141)  a143:q4*d1q3$
(C142)  a443:ev4az*drcq3+coe1*d4q3$
(C143)  a543:-ev5az*drcq3+coe*d5q3$
(C144)  ap1[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C145)  a144:q4*d1q4+ev1$
(C146)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C147)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C148)  ap1[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C149)  a145:q4*d1q5$
(C150)  a445:ev4az*drcq5+coe1*d4q5$
(C151)  a545:-ev5az*drcq5+coe*d5q5$
```

```
(C152)  ap1[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C153)  rctt:rc*tt$
(C154)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C155)  rt:rc*dttq1+tt*drcq1$
(C156)  a151:2*coe*d1q1$
(C157)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C158)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C159)  ap1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C160)  rt:rc*dttq2+tt*drcq2$
(C161)  a152:coe*d1q2-d1q1*q2$
(C162)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C163)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C164)  ap1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C165)  rt:rc*dttq3+tt*drcq3$
(C166)  a153:coe*d1q3-d1q1*q3$
(C167)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C168)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C169)  ap1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C170)  rt:rc*dttq4+tt*drcq4$
(C171)  a154:coe*d1q4-d1q1*q4$
(C172)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C173)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C174)  ap1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C175)  rt:tt*drcq5$
(C176)  a155:coe*d1q5$
(C177)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C178)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C179)  ap1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C180)  q1:q1$
(C181)  q2:q2$
(C182)  q3:q3$
(C183)  q4:-q4$
(C184)  q5:q5$
(C185)  sign:1$
(C186)  cgg1:(gam-1)/gam$
(C187)  cgg2:1/(2*gam)$
(C188)  sada:sqrt(xix**2+xiy**2+xiz**2)$
(C189)  axt:xix/sada$
(C190)  ayt:xiy/sada$
(C191)  azt:xiz/sada$
(C192)  rqrq:q2**2+q3**2+q4**2$
(C193)  q6:1/q1$
(C194)  pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195)  prgam:pr*gam$
(C196)  pp:q5+pr$
(C197)  c:sqrt(prgam*q6)$
(C198)  tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199)  rc:q1*c$
(C200)  csad:c*sada$
(C201)  e1:tt*sada$
(C202)  e4:e1+csad$
```

```
(C203)  e5:e1-csad$
(C204)  ev1:0.0$
(C205)  ev4:0.0$
(C206)  ev5:0.5*(e5+sign*abs(e5))$
(C207)  cg1:0.0$
(C208)  cg2:0.0$
(C209)  cg3:cgg2$
(C210)  d1q1:-ev1*q6$
(C211)  d1q2:xix*q6$
(C212)  d1q3:xiy*q6$
(C213)  d1q4:xiz*q6$
(C214)  d1q5:0.0$
(C215)  coe:gam*(gam-1)/(2*rc)$
(C216)  gm1q6:(gam-1)*q6$
(C217)  drcq1:coe*q5$
(C218)  drcq2:-coe*q2$
(C219)  drcq3:-coe*q3$
(C220)  drcq4:-coe*q4$
(C221)  drcq5:coe*q1$
(C222)  dcq1:(drcq1-c)*q6$
(C223)  dcq2:drcq2*q6$
(C224)  dcq3:drcq3*q6$
(C225)  dcq4:drcq4*q6$
(C226)  dcq5:drcq5*q6$
(C227)  depq1:0.5*gm1q6*rqrq*q6$
(C228)  depq2:-q2*gm1q6$
(C229)  depq3:-q3*gm1q6$
(C230)  depq4:-q4*gm1q6$
(C231)  depq5:gam$
(C232)  dttq1:-tt*q6$
(C233)  dttq2:axt*q6$
(C234)  dttq3:ayt*q6$
(C235)  dttq4:azt*q6$
(C236)  dttq5:0.0$
(C237)  d4q1:sada*(dttq1+dcq1)$
(C238)  d4q2:sada*(dttq2+dcq2)$
(C239)  d4q3:sada*(dttq3+dcq3)$
(C240)  d4q4:sada*(dttq4+dcq4)$
(C241)  d4q5:sada*dcq5$
(C242)  d5q1:sada*(dttq1-dcq1)$
(C243)  d5q2:sada*(dttq2-dcq2)$
(C244)  d5q3:sada*(dttq3-dcq3)$
(C245)  d5q4:sada*(dttq4-dcq4)$
(C246)  d5q5:-d4q5$
(C247)  a411:ev4+q1*d4q1$
(C248)  a511:ev5+q1*d5q1$
(C249)  ap2[1,1]:cg2*a411+cg3*a511$
(C250)  ap2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C251)  ap2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C252)  ap2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C253)  ap2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
```

```
(C254)  rcaxt:rc*axt$
(C255)  ev4ax:ev4*axt$
(C256)  ev5ax:ev5*axt$
(C257)  coe1:q2+rcaxt$
(C258)  coe:q2-rcaxt$
(C259)  a121:q2*d1q1$
(C260)  a421:ev4ax*drcq1+coe1*d4q1$
(C261)  a521:-ev5ax*drcq1+coe*d5q1$
(C262)  ap2[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C263)  a122:q2*d1q2+ev1$
(C264)  a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C265)  a522:ev5-ev5ax*drcq2+coe*d5q2$
(C266)  ap2[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C267)  a123:q2*d1q3$
(C268)  a423:ev4ax*drcq3+coe1*d4q3$
(C269)  a523:-ev5ax*drcq3+coe*d5q3$
(C270)  ap2[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C271)  a124:q2*d1q4$
(C272)  a424:ev4ax*drcq4+coe1*d4q4$
(C273)  a524:-ev5ax*drcq4+coe*d5q4$
(C274)  ap2[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C275)  a125:q2*d1q5$
(C276)  a425:ev4ax*drcq5+coe1*d4q5$
(C277)  a525:-ev5ax*drcq5+coe*d5q5$
(C278)  ap2[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C279)  rcayt:rc*ayt$
(C280)  ev4ay:ev4*ayt$
(C281)  ev5ay:ev5*ayt$
(C282)  coe1:q3+rcayt$
(C283)  coe:q3-rcayt$
(C284)  a131:q3*d1q1$
(C285)  a431:ev4ay*drcq1+coe1*d4q1$
(C286)  a531:-ev5ay*drcq1+coe*d5q1$
(C287)  ap2[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C288)  a132:q3*d1q2$
(C289)  a432:ev4ay*drcq2+coe1*d4q2$
(C290)  a532:-ev5ay*drcq2+coe*d5q2$
(C291)  ap2[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C292)  a133:q3*d1q3+ev1$
(C293)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C294)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C295)  ap2[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C296)  a134:q3*d1q4$
(C297)  a434:ev4ay*drcq4+coe1*d4q4$
(C298)  a534:-ev5ay*drcq4+coe*d5q4$
(C299)  ap2[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C300)  a135:q3*d1q5$
(C301)  a435:ev4ay*drcq5+coe1*d4q5$
(C302)  a535:-ev5ay*drcq5+coe*d5q5$
(C303)  ap2[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C304)  rcazt:rc*azt$
```

```
(C305)  ev4az:ev4*azt$
(C306)  ev5az:ev5*azt$
(C307)  coe1:q4+rcazt$
(C308)  coe:q4-rcazt$
(C309)  a141:q4*d1q1$
(C310)  a441:ev4az*drcq1+coe1*d4q1$
(C311)  a541:-ev5az*drcq1+coe*d5q1$
(C312)  ap2[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C313)  a142:q4*d1q2$
(C314)  a442:ev4az*drcq2+coe1*d4q2$
(C315)  a542:-ev5az*drcq2+coe*d5q2$
(C316)  ap2[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C317)  a143:q4*d1q3$
(C318)  a443:ev4az*drcq3+coe1*d4q3$
(C319)  a543:-ev5az*drcq3+coe*d5q3$
(C320)  ap2[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C321)  a144:q4*d1q4+ev1$
(C322)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C323)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C324)  ap2[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C325)  a145:q4*d1q5$
(C326)  a445:ev4az*drcq5+coe1*d4q5$
(C327)  a545:-ev5az*drcq5+coe*d5q5$
(C328)  ap2[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C329)  rctt:rc*tt$
(C330)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C331)  rt:rc*dttq1+tt*drcq1$
(C332)  a151:2*coe*d1q1$
(C333)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C334)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C335)  ap2[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C336)  rt:rc*dttq2+tt*drcq2$
(C337)  a152:coe*d1q2-d1q1*q2$
(C338)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C339)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C340)  ap2[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C341)  rt:rc*dttq3+tt*drcq3$
(C342)  a153:coe*d1q3-d1q1*q3$
(C343)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C344)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C345)  ap2[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C346)  rt:rc*dttq4+tt*drcq4$
(C347)  a154:coe*d1q4-d1q1*q4$
(C348)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C349)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C350)  ap2[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C351)  rt:tt*drcq5$
(C352)  a155:coe*d1q5$
(C353)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C354)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C355)  ap2[5,5]:cg1*a155+cg2*a455+cg3*a555$
```

```
(C356) diff:ap1.m-m.ap2$
(C357) diff:ratexpand(diff);
```

$$
\begin{bmatrix}
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0
\end{bmatrix}
$$

(D357)

```
(C358) closefile(Amsub)$
```

```
(C3)  bp1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4)  bp2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5)  diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C6)  m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C7)  sign:1$
(C8)  cgg1:(gam-1)/gam$
(C9)  cgg2:1/(2*gam)$
(C10) etx:0.0$
(C11) sada:sqrt(etx**2+ety**2+etz**2)$
(C12) axt:etx/sada$
(C13) ayt:ety/sada$
(C14) azt:etz/sada$
(C15) rqrq:q2**2+q3**2+q4**2$
(C16) q6:1/q1$
(C17) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C18) prgam:pr*gam$
(C19) pp:q5+pr$
(C20) c:sqrt(prgam*q6)$
(C21) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C22) rc:q1*c$
(C23) csad:c*sada$
(C24) e1:tt*sada$
(C25) e4:e1+csad$
(C26) e5:e1-csad$
(C27) ev1:0.5*(e1+sign*abs(e1))$
(C28) ev4:0.5*(e4+sign*abs(e4))$
(C29) ev5:0.5*(e5+sign*abs(e5))$
(C30) cg1:cgg1$
(C31) cg2:cgg2$
(C32) cg3:cgg2$
(C33) d1q1:-ev1*q6$
(C34) d1q2:etx*q6$
(C35) d1q3:ety*q6$
(C36) d1q4:etz*q6$
(C37) d1q5:0.0$
(C38) coe:gam*(gam-1)/(2*rc)$
(C39) gm1q6:(gam-1)*q6$
(C40) drcq1:coe*q5$
(C41) drcq2:-coe*q2$
(C42) drcq3:-coe*q3$
(C43) drcq4:-coe*q4$
(C44) drcq5:coe*q1$
(C45) dcq1:(drcq1-c)*q6$
(C46) dcq2:drcq2*q6$
(C47) dcq3:drcq3*q6$
(C48) dcq4:drcq4*q6$
(C49) dcq5:drcq5*q6$
```

```
(C50)   depq1:0.5*gm1q6*rqrq*q6$
(C51)   depq2:-q2*gm1q6$
(C52)   depq3:-q3*gm1q6$
(C53)   depq4:-q4*gm1q6$
(C54)   depq5:gam$
(C55)   dttq1:-tt*q6$
(C56)   dttq2:axt*q6$
(C57)   dttq3:ayt*q6$
(C58)   dttq4:azt*q6$
(C59)   dttq5:0.0$
(C60)   d4q1:sada*(dttq1+dcq1)$
(C61)   d4q2:sada*(dttq2+dcq2)$
(C62)   d4q3:sada*(dttq3+dcq3)$
(C63)   d4q4:sada*(dttq4+dcq4)$
(C64)   d4q5:sada*dcq5$
(C65)   d5q1:sada*(dttq1-dcq1)$
(C66)   d5q2:sada*(dttq2-dcq2)$
(C67)   d5q3:sada*(dttq3-dcq3)$
(C68)   d5q4:sada*(dttq4-dcq4)$
(C69)   d5q5:-d4q5$
(C70)   a411:ev4+q1*d4q1$
(C71)   a511:ev5+q1*d5q1$
(C72)   bp1[1,1]:cg2*a411+cg3*a511$
(C73)   bp1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C74)   bp1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C75)   bp1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C76)   bp1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C77)   rcaxt:rc*axt$
(C78)   ev4ax:ev4*axt$
(C79)   ev5ax:ev5*axt$
(C80)   coe1:q2+rcaxt$
(C81)   coe:q2-rcaxt$
(C82)   a121:q2*d1q1$
(C83)   a421:ev4ax*drcq1+coe1*d4q1$
(C84)   a521:-ev5ax*drcq1+coe*d5q1$
(C85)   bp1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C86)   a122:q2*d1q2+ev1$
(C87)   a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C88)   a522:ev5-ev5ax*drcq2+coe*d5q2$
(C89)   bp1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C90)   a123:q2*d1q3$
(C91)   a423:ev4ax*drcq3+coe1*d4q3$
(C92)   a523:-ev5ax*drcq3+coe*d5q3$
(C93)   bp1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C94)   a124:q2*d1q4$
(C95)   a424:ev4ax*drcq4+coe1*d4q4$
(C96)   a524:-ev5ax*drcq4+coe*d5q4$
(C97)   bp1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C98)   a125:q2*d1q5$
(C99)   a425:ev4ax*drcq5+coe1*d4q5$
(C100)  a525:-ev5ax*drcq5+coe*d5q5$
```

```
(C101)  bp1[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C102)  rcayt:rc*ayt$
(C103)  ev4ay:ev4*ayt$
(C104)  ev5ay:ev5*ayt$
(C105)  coe1:q3+rcayt$
(C106)  coe:q3-rcayt$
(C107)  a131:q3*d1q1$
(C108)  a431:ev4ay*drcq1+coe1*d4q1$
(C109)  a531:-ev5ay*drcq1+coe*d5q1$
(C110)  bp1[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C111)  a132:q3*d1q2$
(C112)  a432:ev4ay*drcq2+coe1*d4q2$
(C113)  a532:-ev5ay*drcq2+coe*d5q2$
(C114)  bp1[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C115)  a133:q3*d1q3+ev1$
(C116)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C117)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C118)  bp1[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C119)  a134:q3*d1q4$
(C120)  a434:ev4ay*drcq4+coe1*d4q4$
(C121)  a534:-ev5ay*drcq4+coe*d5q4$
(C122)  bp1[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C123)  a135:q3*d1q5$
(C124)  a435:ev4ay*drcq5+coe1*d4q5$
(C125)  a535:-ev5ay*drcq5+coe*d5q5$
(C126)  bp1[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C127)  rcazt:rc*azt$
(C128)  ev4az:ev4*azt$
(C129)  ev5az:ev5*azt$
(C130)  coe1:q4+rcazt$
(C131)  coe:q4-rcazt$
(C132)  a141:q4*d1q1$
(C133)  a441:ev4az*drcq1+coe1*d4q1$
(C134)  a541:-ev5az*drcq1+coe*d5q1$
(C135)  bp1[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C136)  a142:q4*d1q2$
(C137)  a442:ev4az*drcq2+coe1*d4q2$
(C138)  a542:-ev5az*drcq2+coe*d5q2$
(C139)  bp1[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C140)  a143:q4*d1q3$
(C141)  a443:ev4az*drcq3+coe1*d4q3$
(C142)  a543:-ev5az*drcq3+coe*d5q3$
(C143)  bp1[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C144)  a144:q4*d1q4+ev1$
(C145)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C146)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C147)  bp1[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C148)  a145:q4*d1q5$
(C149)  a445:ev4az*drcq5+coe1*d4q5$
(C150)  a545:-ev5az*drcq5+coe*d5q5$
(C151)  bp1[4,5]:cg1*a145+cg2*a445+cg3*a545$
```

```
(C152)  rctt:rc*tt$
(C153)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C154)  rt:rc*dttq1+tt*drcq1$
(C155)  a151:2*coe*d1q1$
(C156)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C157)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C158)  bp1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C159)  rt:rc*dttq2+tt*drcq2$
(C160)  a152:coe*d1q2-d1q1*q2$
(C161)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C162)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C163)  bp1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C164)  rt:rc*dttq3+tt*drcq3$
(C165)  a153:coe*d1q3-d1q1*q3$
(C166)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C167)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C168)  bp1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C169)  rt:rc*dttq4+tt*drcq4$
(C170)  a154:coe*d1q4-d1q1*q4$
(C171)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C172)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C173)  bp1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C174)  rt:tt*drcq5$
(C175)  a155:coe*d1q5$
(C176)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C177)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C178)  bp1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C179)  q1:q1$
(C180)  q2:q2$
(C181)  q3:q3$
(C182)  q4:-q4$
(C183)  q5:q5$
(C184)  sign:1$
(C185)  etz:-etz;
(C186)  cgg1:(gam-1)/gam$
(C187)  cgg2:1/(2*gam)$
(C188)  sada:sqrt(etx**2+ety**2+etz**2)$
(C189)  axt:etx/sada$
(C190)  ayt:ety/sada$
(C191)  azt:etz/sada$
(C192)  rqrq:q2**2+q3**2+q4**2$
(C193)  q6:1/q1$
(C194)  pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195)  prgam:pr*gam$
(C196)  pp:q5+pr$
(C197)  c:sqrt(prgam*q6)$
(C198)  tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199)  rc:q1*c$
(C200)  csad:c*sada$
(C201)  e1:tt*sada$
(C202)  e4:e1+csad$
```

```
(C203)  e5:e1-csad$
(C204)  ev1:0.5*(e1+sign*abs(e1))$
(C205)  ev4:0.5*(e4+sign*abs(e4))$
(C206)  ev5:0.5*(e5+sign*abs(e5))$
(C207)  cg1:cgg1$
(C208)  cg2:cgg2$
(C209)  cg3:cgg2$
(C210)  d1q1:-ev1*q6$
(C211)  d1q2:etx*q6$
(C212)  d1q3:ety*q6$
(C213)  d1q4:etz*q6$
(C214)  d1q5:0.0$
(C215)  coe:gam*(gam-1)/(2*rc)$
(C216)  gm1q6:(gam-1)*q6$
(C217)  drcq1:coe*q5$
(C218)  drcq2:-coe*q2$
(C219)  drcq3:-coe*q3$
(C220)  drcq4:-coe*q4$
(C221)  drcq5:coe*q1$
(C222)  dcq1:(drcq1-c)*q6$
(C223)  dcq2:drcq2*q6$
(C224)  dcq3:drcq3*q6$
(C225)  dcq4:drcq4*q6$
(C226)  dcq5:drcq5*q6$
(C227)  depq1:0.5*gm1q6*rqrq*q6$
(C228)  depq2:-q2*gm1q6$
(C229)  depq3:-q3*gm1q6$
(C230)  depq4:-q4*gm1q6$
(C231)  depq5:gam$
(C232)  dttq1:-tt*q6$
(C233)  dttq2:axt*q6$
(C234)  dttq3:ayt*q6$
(C235)  dttq4:azt*q6$
(C236)  dttq5:0.0$
(C237)  d4q1:sada*(dttq1+dcq1)$
(C238)  d4q2:sada*(dttq2+dcq2)$
(C239)  d4q3:sada*(dttq3+dcq3)$
(C240)  d4q4:sada*(dttq4+dcq4)$
(C241)  d4q5:sada*dcq5$
(C242)  d5q1:sada*(dttq1-dcq1)$
(C243)  d5q2:sada*(dttq2-dcq2)$
(C244)  d5q3:sada*(dttq3-dcq3)$
(C245)  d5q4:sada*(dttq4-dcq4)$
(C246)  d5q5:-d4q5$
(C247)  a411:ev4+q1*d4q1$
(C248)  a511:ev5+q1*d5q1$
(C249)  bp2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C250)  bp2[1,1]:cg2*a411+cg3*a511$
(C251)  bp2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C252)  bp2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
```

```
(C253)  bp2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C254)  bp2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C255)  rcaxt:rc*axt$
(C256)  ev4ax:ev4*axt$
(C257)  ev5ax:ev5*axt$
(C258)  coe1:q2+rcaxt$
(C259)  coe:q2-rcaxt$
(C260)  a121:q2*d1q1$
(C261)  a421:ev4ax*drcq1+coe1*d4q1$
(C262)  a521:-ev5ax*drcq1+coe*d5q1$
(C263)  bp2[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C264)  a122:q2*d1q2+ev1$
(C265)  a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C266)  a522:ev5-ev5ax*drcq2+coe*d5q2$
(C267)  bp2[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C268)  a123:q2*d1q3$
(C269)  a423:ev4ax*drcq3+coe1*d4q3$
(C270)  a523:-ev5ax*drcq3+coe*d5q3$
(C271)  bp2[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C272)  a124:q2*d1q4$
(C273)  a424:ev4ax*drcq4+coe1*d4q4$
(C274)  a524:-ev5ax*drcq4+coe*d5q4$
(C275)  bp2[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C276)  a125:q2*d1q5$
(C277)  a425:ev4ax*drcq5+coe1*d4q5$
(C278)  a525:-ev5ax*drcq5+coe*d5q5$
(C279)  bp2[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C280)  rcayt:rc*ayt$
(C281)  ev4ay:ev4*ayt$
(C282)  ev5ay:ev5*ayt$
(C283)  coe1:q3+rcayt$
(C284)  coe:q3-rcayt$
(C285)  a131:q3*d1q1$
(C286)  a431:ev4ay*drcq1+coe1*d4q1$
(C287)  a531:-ev5ay*drcq1+coe*d5q1$
(C288)  bp2[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C289)  a132:q3*d1q2$
(C290)  a432:ev4ay*drcq2+coe1*d4q2$
(C291)  a532:-ev5ay*drcq2+coe*d5q2$
(C292)  bp2[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C293)  a133:q3*d1q3+ev1$
(C294)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C295)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C296)  bp2[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C297)  a134:q3*d1q4$
(C298)  a434:ev4ay*drcq4+coe1*d4q4$
(C299)  a534:-ev5ay*drcq4+coe*d5q4$
(C300)  bp2[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C301)  a135:q3*d1q5$
(C302)  a435:ev4ay*drcq5+coe1*d4q5$
(C303)  a535:-ev5ay*drcq5+coe*d5q5$
```

```
(C304)  bp2[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C305)  rcazt:rc*azt$
(C306)  ev4az:ev4*azt$
(C307)  ev5az:ev5*azt$
(C308)  coe1:q4+rcazt$
(C309)  coe:q4-rcazt$
(C310)  a141:q4*d1q1$
(C311)  a441:ev4az*drcq1+coe1*d4q1$
(C312)  a541:-ev5az*drcq1+coe*d5q1$
(C313)  bp2[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C314)  a142:q4*d1q2$
(C315)  a442:ev4az*drcq2+coe1*d4q2$
(C316)  a542:-ev5az*drcq2+coe*d5q2$
(C317)  bp2[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C318)  a143:q4*d1q3$
(C319)  a443:ev4az*drcq3+coe1*d4q3$
(C320)  a543:-ev5az*drcq3+coe*d5q3$
(C321)  bp2[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C322)  a144:q4*d1q4+ev1$
(C323)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C324)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C325)  bp2[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C326)  a145:q4*d1q5$
(C327)  a445:ev4az*drcq5+coe1*d4q5$
(C328)  a545:-ev5az*drcq5+coe*d5q5$
(C329)  bp2[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C330)  rctt:rc*tt$
(C331)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C332)  rt:rc*dttq1+tt*drcq1$
(C333)  a151:2*coe*d1q1$
(C334)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C335)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C336)  bp2[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C337)  rt:rc*dttq2+tt*drcq2$
(C338)  a152:coe*d1q2-d1q1*q2$
(C339)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C340)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C341)  bp2[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C342)  rt:rc*dttq3+tt*drcq3$
(C343)  a153:coe*d1q3-d1q1*q3$
(C344)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C345)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C346)  bp2[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C347)  rt:rc*dttq4+tt*drcq4$
(C348)  a154:coe*d1q4-d1q1*q4$
(C349)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C350)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C351)  bp2[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C352)  rt:tt*drcq5$
(C353)  a155:coe*d1q5$
(C354)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
```

```
(C355) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C356) bp2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C357) diff:bp1.m-m.bp2$
(C358) diff:ratexpand(diff);
```

$$
(D358) \quad
\begin{bmatrix}
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0
\end{bmatrix}
$$

```
(C359) closefile(Bpsup)$
```

```
(C3)  bp1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4)  bp2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5)  diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C6)  m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C7)  sign:1$
(C8)  cgg1:(gam-1)/gam$
(C9)  cgg2:1/(2*gam)$
(C10) etx:0.0$
(C11) sada:sqrt(etx**2+ety**2+etz**2)$
(C12) axt:etx/sada$
(C13) ayt:ety/sada$
(C14) azt:etz/sada$
(C15) rqrq:q2**2+q3**2+q4**2$
(C16) q6:1/q1$
(C17) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C18) prgam:pr*gam$
(C19) pp:q5+pr$
(C20) c:sqrt(prgam*q6)$
(C21) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C22) rc:q1*c$
(C23) csad:c*sada$
(C24) e1:tt*sada$
(C25) e4:e1+csad$
(C26) e5:e1-csad$
(C27) ev1:0.5*(e1+sign*abs(e1))$
(C28) ev4:0.5*(e4+sign*abs(e4))$
(C29) ev5:0.0$
(C30) cg1:cgg1$
(C31) cg2:cgg2$
(C32) cg3:0.0$
(C33) d1q1:-ev1*q6$
(C34) d1q2:etx*q6$
(C35) d1q3:ety*q6$
(C36) d1q4:etz*q6$
(C37) d1q5:0.0$
(C38) coe:gam*(gam-1)/(2*rc)$
(C39) gm1q6:(gam-1)*q6$
(C40) drcq1:coe*q5$
(C41) drcq2:-coe*q2$
(C42) drcq3:-coe*q3$
(C43) drcq4:-coe*q4$
(C44) drcq5:coe*q1$
(C45) dcq1:(drcq1-c)*q6$
(C46) dcq2:drcq2*q6$
(C47) dcq3:drcq3*q6$
(C48) dcq4:drcq4*q6$
(C49) dcq5:drcq5*q6$
```

```
(C50)   depq1:0.5*gm1q6*rqrq*q6$
(C51)   depq2:-q2*gm1q6$
(C52)   depq3:-q3*gm1q6$
(C53)   depq4:-q4*gm1q6$
(C54)   depq5:gam$
(C55)   dttq1:-tt*q6$
(C56)   dttq2:axt*q6$
(C57)   dttq3:ayt*q6$
(C58)   dttq4:azt*q6$
(C59)   dttq5:0.0$
(C60)   d4q1:sada*(dttq1+dcq1)$
(C61)   d4q2:sada*(dttq2+dcq2)$
(C62)   d4q3:sada*(dttq3+dcq3)$
(C63)   d4q4:sada*(dttq4+dcq4)$
(C64)   d4q5:sada*dcq5$
(C65)   d5q1:sada*(dttq1-dcq1)$
(C66)   d5q2:sada*(dttq2-dcq2)$
(C67)   d5q3:sada*(dttq3-dcq3)$
(C68)   d5q4:sada*(dttq4-dcq4)$
(C69)   d5q5:-d4q5$
(C70)   a411:ev4+q1*d4q1$
(C71)   a511:ev5+q1*d5q1$
(C72)   bp1[1,1]:cg2*a411+cg3*a511$
(C73)   bp1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C74)   bp1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C75)   bp1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C76)   bp1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C77)   rcaxt:rc*axt$
(C78)   ev4ax:ev4*axt$
(C79)   ev5ax:ev5*axt$
(C80)   coe1:q2+rcaxt$
(C81)   coe:q2-rcaxt$
(C82)   a121:q2*d1q1$
(C83)   a421:ev4ax*drcq1+coe1*d4q1$
(C84)   a521:-ev5ax*drcq1+coe*d5q1$
(C85)   bp1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C86)   a122:q2*d1q2+ev1$
(C87)   a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C88)   a522:ev5-ev5ax*drcq2+coe*d5q2$
(C89)   bp1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C90)   a123:q2*d1q3$
(C91)   a423:ev4ax*drcq3+coe1*d4q3$
(C92)   a523:-ev5ax*drcq3+coe*d5q3$
(C93)   bp1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C94)   a124:q2*d1q4$
(C95)   a424:ev4ax*drcq4+coe1*d4q4$
(C96)   a524:-ev5ax*drcq4+coe*d5q4$
(C97)   bp1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C98)   a125:q2*d1q5$
(C99)   a425:ev4ax*drcq5+coe1*d4q5$
(C100)  a525:-ev5ax*drcq5+coe*d5q5$
```

```
(C101)  bp1[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C102)  rcayt:rc*ayt$
(C103)  ev4ay:ev4*ayt$
(C104)  ev5ay:ev5*ayt$
(C105)  coe1:q3+rcayt$
(C106)  coe:q3-rcayt$
(C107)  a131:q3*d1q1$
(C108)  a431:ev4ay*drcq1+coe1*d4q1$
(C109)  a531:-ev5ay*drcq1+coe*d5q1$
(C110)  bp1[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C111)  a132:q3*d1q2$
(C112)  a432:ev4ay*drcq2+coe1*d4q2$
(C113)  a532:-ev5ay*drcq2+coe*d5q2$
(C114)  bp1[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C115)  a133:q3*d1q3+ev1$
(C116)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C117)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C118)  bp1[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C119)  a134:q3*d1q4$
(C120)  a434:ev4ay*drcq4+coe1*d4q4$
(C121)  a534:-ev5ay*drcq4+coe*d5q4$
(C122)  bp1[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C123)  a135:q3*d1q5$
(C124)  a435:ev4ay*drcq5+coe1*d4q5$
(C125)  a535:-ev5ay*drcq5+coe*d5q5$
(C126)  bp1[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C127)  rcazt:rc*azt$
(C128)  ev4az:ev4*azt$
(C129)  ev5az:ev5*azt$
(C130)  coe1:q4+rcazt$
(C131)  coe:q4-rcazt$
(C132)  a141:q4*d1q1$
(C133)  a441:ev4az*drcq1+coe1*d4q1$
(C134)  a541:-ev5az*drcq1+coe*d5q1$
(C135)  bp1[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C136)  a142:q4*d1q2$
(C137)  a442:ev4az*drcq2+coe1*d4q2$
(C138)  a542:-ev5az*drcq2+coe*d5q2$
(C139)  bp1[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C140)  a143:q4*d1q3$
(C141)  a443:ev4az*drcq3+coe1*d4q3$
(C142)  a543:-ev5az*drcq3+coe*d5q3$
(C143)  bp1[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C144)  a144:q4*d1q4+ev1$
(C145)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C146)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C147)  bp1[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C148)  a145:q4*d1q5$
(C149)  a445:ev4az*drcq5+coe1*d4q5$
(C150)  a545:-ev5az*drcq5+coe*d5q5$
(C151)  bp1[4,5]:cg1*a145+cg2*a445+cg3*a545$
```

```
(C152)  rctt:rc*tt$
(C153)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C154)  rt:rc*dttq1+tt*drcq1$
(C155)  a151:2*coe*d1q1$
(C156)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C157)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C158)  bp1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C159)  rt:rc*dttq2+tt*drcq2$
(C160)  a152:coe*d1q2-d1q1*q2$
(C161)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C162)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C163)  bp1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C164)  rt:rc*dttq3+tt*drcq3$
(C165)  a153:coe*d1q3-d1q1*q3$
(C166)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C167)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C168)  bp1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C169)  rt:rc*dttq4+tt*drcq4$
(C170)  a154:coe*d1q4-d1q1*q4$
(C171)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C172)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C173)  bp1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C174)  rt:tt*drcq5$
(C175)  a155:coe*d1q5$
(C176)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C177)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C178)  bp1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C179)  q1:q1$
(C180)  q2:q2$
(C181)  q3:q3$
(C182)  q4:-q4$
(C183)  q5:q5$
(C184)  sign:1$
(C185)  etz:-etz;
(C186)  cgg1:(gam-1)/gam$
(C187)  cgg2:1/(2*gam)$
(C188)  sada:sqrt(etx**2+ety**2+etz**2)$
(C189)  axt:etx/sada$
(C190)  ayt:ety/sada$
(C191)  azt:etz/sada$
(C192)  rqrq:q2**2+q3**2+q4**2$
(C193)  q6:1/q1$
(C194)  pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195)  prgam:pr*gam$
(C196)  pp:q5+pr$
(C197)  c:sqrt(prgam*q6)$
(C198)  tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199)  rc:q1*c$
(C200)  csad:c*sada$
(C201)  e1:tt*sada$
(C202)  e4:e1+csad$
```

```
(C203)  e5:e1-csad$
(C204)  ev1:0.5*(e1+sign*abs(e1))$
(C205)  ev4:0.5*(e4+sign*abs(e4))$
(C206)  ev5:0.0$
(C207)  cg1:cgg1$
(C208)  cg2:cgg2$
(C209)  cg3:0.0$
(C210)  d1q1:-ev1*q6$
(C211)  d1q2:etx*q6$
(C212)  d1q3:ety*q6$
(C213)  d1q4:etz*q6$
(C214)  d1q5:0.0$
(C215)  coe:gam*(gam-1)/(2*rc)$
(C216)  gm1q6:(gam-1)*q6$
(C217)  drcq1:coe*q5$
(C218)  drcq2:-coe*q2$
(C219)  drcq3:-coe*q3$
(C220)  drcq4:-coe*q4$
(C221)  drcq5:coe*q1$
(C222)  dcq1:(drcq1-c)*q6$
(C223)  dcq2:drcq2*q6$
(C224)  dcq3:drcq3*q6$
(C225)  dcq4:drcq4*q6$
(C226)  dcq5:drcq5*q6$
(C227)  depq1:0.5*gm1q6*rqrq*q6$
(C228)  depq2:-q2*gm1q6$
(C229)  depq3:-q3*gm1q6$
(C230)  depq4:-q4*gm1q6$
(C231)  depq5:gam$
(C232)  dttq1:-tt*q6$
(C233)  dttq2:axt*q6$
(C234)  dttq3:ayt*q6$
(C235)  dttq4:azt*q6$
(C236)  dttq5:0.0$
(C237)  d4q1:sada*(dttq1+dcq1)$
(C238)  d4q2:sada*(dttq2+dcq2)$
(C239)  d4q3:sada*(dttq3+dcq3)$
(C240)  d4q4:sada*(dttq4+dcq4)$
(C241)  d4q5:sada*dcq5$
(C242)  d5q1:sada*(dttq1-dcq1)$
(C243)  d5q2:sada*(dttq2-dcq2)$
(C244)  d5q3:sada*(dttq3-dcq3)$
(C245)  d5q4:sada*(dttq4-dcq4)$
(C246)  d5q5:-d4q5$
(C247)  a411:ev4+q1*d4q1$
(C248)  a511:ev5+q1*d5q1$
(C249)  bp2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C250)  bp2[1,1]:cg2*a411+cg3*a511$
(C251)  bp2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C252)  bp2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
```

```
(C253)  bp2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C254)  bp2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C255)  rcaxt:rc*axt$
(C256)  ev4ax:ev4*axt$
(C257)  ev5ax:ev5*axt$
(C258)  coe1:q2+rcaxt$
(C259)  coe:q2-rcaxt$
(C260)  a121:q2*d1q1$
(C261)  a421:ev4ax*drcq1+coe1*d4q1$
(C262)  a521:-ev5ax*drcq1+coe*d5q1$
(C263)  bp2[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C264)  a122:q2*d1q2+ev1$
(C265)  a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C266)  a522:ev5-ev5ax*drcq2+coe*d5q2$
(C267)  bp2[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C268)  a123:q2*d1q3$
(C269)  a423:ev4ax*drcq3+coe1*d4q3$
(C270)  a523:-ev5ax*drcq3+coe*d5q3$
(C271)  bp2[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C272)  a124:q2*d1q4$
(C273)  a424:ev4ax*drcq4+coe1*d4q4$
(C274)  a524:-ev5ax*drcq4+coe*d5q4$
(C275)  bp2[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C276)  a125:q2*d1q5$
(C277)  a425:ev4ax*drcq5+coe1*d4q5$
(C278)  a525:-ev5ax*drcq5+coe*d5q5$
(C279)  bp2[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C280)  rcayt:rc*ayt$
(C281)  ev4ay:ev4*ayt$
(C282)  ev5ay:ev5*ayt$
(C283)  coe1:q3+rcayt$
(C284)  coe:q3-rcayt$
(C285)  a131:q3*d1q1$
(C286)  a431:ev4ay*drcq1+coe1*d4q1$
(C287)  a531:-ev5ay*drcq1+coe*d5q1$
(C288)  bp2[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C289)  a132:q3*d1q2$
(C290)  a432:ev4ay*drcq2+coe1*d4q2$
(C291)  a532:-ev5ay*drcq2+coe*d5q2$
(C292)  bp2[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C293)  a133:q3*d1q3+ev1$
(C294)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C295)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C296)  bp2[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C297)  a134:q3*d1q4$
(C298)  a434:ev4ay*drcq4+coe1*d4q4$
(C299)  a534:-ev5ay*drcq4+coe*d5q4$
(C300)  bp2[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C301)  a135:q3*d1q5$
(C302)  a435:ev4ay*drcq5+coe1*d4q5$
(C303)  a535:-ev5ay*drcq5+coe*d5q5$
```

```
(C304)  bp2[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C305)  rcazt:rc*azt$
(C306)  ev4az:ev4*azt$
(C307)  ev5az:ev5*azt$
(C308)  coe1:q4+rcazt$
(C309)  coe:q4-rcazt$
(C310)  a141:q4*d1q1$
(C311)  a441:ev4az*drcq1+coe1*d4q1$
(C312)  a541:-ev5az*drcq1+coe*d5q1$
(C313)  bp2[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C314)  a142:q4*d1q2$
(C315)  a442:ev4az*drcq2+coe1*d4q2$
(C316)  a542:-ev5az*drcq2+coe*d5q2$
(C317)  bp2[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C318)  a143:q4*d1q3$
(C319)  a443:ev4az*drcq3+coe1*d4q3$
(C320)  a543:-ev5az*drcq3+coe*d5q3$
(C321)  bp2[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C322)  a144:q4*d1q4+ev1$
(C323)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C324)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C325)  bp2[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C326)  a145:q4*d1q5$
(C327)  a445:ev4az*drcq5+coe1*d4q5$
(C328)  a545:-ev5az*drcq5+coe*d5q5$
(C329)  bp2[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C330)  rctt:rc*tt$
(C331)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C332)  rt:rc*dttq1+tt*drcq1$
(C333)  a151:2*coe*d1q1$
(C334)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C335)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C336)  bp2[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C337)  rt:rc*dttq2+tt*drcq2$
(C338)  a152:coe*d1q2-d1q1*q2$
(C339)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C340)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C341)  bp2[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C342)  rt:rc*dttq3+tt*drcq3$
(C343)  a153:coe*d1q3-d1q1*q3$
(C344)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C345)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C346)  bp2[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C347)  rt:rc*dttq4+tt*drcq4$
(C348)  a154:coe*d1q4-d1q1*q4$
(C349)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C350)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C351)  bp2[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C352)  rt:tt*drcq5$
(C353)  a155:coe*d1q5$
(C354)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
```

```
(C355)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C356)  bp2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C357)  diff:bp1.m-m.bp2$
(C358)  diff:ratexpand(diff);
```

$$
\begin{bmatrix}
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0
\end{bmatrix}
$$

(D358)

```
(C359)  closefile(Bpsub)$
```

```
(C3)  bm1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4)  bm2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5)  m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C6)  diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C7)  sign:-1$
(C8)  cgg1:(gam-1)/gam$
(C9)  cgg2:1/(2*gam)$
(C10) etx:0.0$
(C11) sada:sqrt(etx**2+ety**2+etz**2)$
(C12) axt:etx/sada$
(C13) ayt:ety/sada$
(C14) azt:etz/sada$
(C15) rqrq:q2**2+q3**2+q4**2$
(C16) q6:1/q1$
(C17) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C18) prgam:pr*gam$
(C19) pp:q5+pr$
(C20) c:sqrt(prgam*q6)$
(C21) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C22) rc:q1*c$
(C23) csad:c*sada$
(C24) e1:tt*sada$
(C25) e4:e1+csad$
(C26) e5:e1-csad$
(C27) ev1:0.0$
(C28) ev4:0.0$
(C29) ev5:0.0$
(C30) cg1:0.0$
(C31) cg2:0.0$
(C32) cg3:0.0$
(C33) d1q1:-ev1*q6$
(C34) d1q2:etx*q6$
(C35) d1q3:ety*q6$
(C36) d1q4:etz*q6$
(C37) d1q5:0.0$
(C38) coe:gam*(gam-1)/(2*rc)$
(C39) gm1q6:(gam-1)*q6$
(C40) drcq1:coe*q5$
(C41) drcq2:-coe*q2$
(C42) drcq3:-coe*q3$
(C43) drcq4:-coe*q4$
(C44) drcq5:coe*q1$
(C45) dcq1:(drcq1-c)*q6$
(C46) dcq2:drcq2*q6$
(C47) dcq3:drcq3*q6$
(C48) dcq4:drcq4*q6$
(C49) dcq5:drcq5*q6$
```

```
(C50)   depq1:0.5*gm1q6*rqrq*q6$
(C51)   depq2:-q2*gm1q6$
(C52)   depq3:-q3*gm1q6$
(C53)   depq4:-q4*gm1q6$
(C54)   depq5:gam$
(C55)   dttq1:-tt*q6$
(C56)   dttq2:axt*q6$
(C57)   dttq3:ayt*q6$
(C58)   dttq4:azt*q6$
(C59)   dttq5:0.0$
(C60)   d4q1:sada*(dttq1+dcq1)$
(C61)   d4q2:sada*(dttq2+dcq2)$
(C62)   d4q3:sada*(dttq3+dcq3)$
(C63)   d4q4:sada*(dttq4+dcq4)$
(C64)   d4q5:sada*dcq5$
(C65)   d5q1:sada*(dttq1-dcq1)$
(C66)   d5q2:sada*(dttq2-dcq2)$
(C67)   d5q3:sada*(dttq3-dcq3)$
(C68)   d5q4:sada*(dttq4-dcq4)$
(C69)   d5q5:-d4q5$
(C70)   a411:ev4+q1*d4q1$
(C71)   a511:ev5+q1*d5q1$
(C72)   bm1[1,1]:cg2*a411+cg3*a511$
(C73)   bm1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C74)   bm1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C75)   bm1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C76)   bm1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C77)   rcaxt:rc*axt$
(C78)   ev4ax:ev4*axt$
(C79)   ev5ax:ev5*axt$
(C80)   coe1:q2+rcaxt$
(C81)   coe:q2-rcaxt$
(C82)   a121:q2*d1q1$
(C83)   a421:ev4ax*drcq1+coe1*d4q1$
(C84)   a521:-ev5ax*drcq1+coe*d5q1$
(C85)   bm1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C86)   a122:q2*d1q2+ev1$
(C87)   a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C88)   a522:ev5-ev5ax*drcq2+coe*d5q2$
(C89)   bm1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C90)   a123:q2*d1q3$
(C91)   a423:ev4ax*drcq3+coe1*d4q3$
(C92)   a523:-ev5ax*drcq3+coe*d5q3$
(C93)   bm1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C94)   a124:q2*d1q4$
(C95)   a424:ev4ax*drcq4+coe1*d4q4$
(C96)   a524:-ev5ax*drcq4+coe*d5q4$
(C97)   bm1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C98)   a125:q2*d1q5$
(C99)   a425:ev4ax*drcq5+coe1*d4q5$
(C100)  a525:-ev5ax*drcq5+coe*d5q5$
```

```
(C101)  bm1[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C102)  rcayt:rc*ayt$
(C103)  ev4ay:ev4*ayt$
(C104)  ev5ay:ev5*ayt$
(C105)  coe1:q3+rcayt$
(C106)  coe:q3-rcayt$
(C107)  a131:q3*d1q1$
(C108)  a431:ev4ay*drcq1+coe1*d4q1$
(C109)  a531:-ev5ay*drcq1+coe*d5q1$
(C110)  bm1[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C111)  a132:q3*d1q2$
(C112)  a432:ev4ay*drcq2+coe1*d4q2$
(C113)  a532:-ev5ay*drcq2+coe*d5q2$
(C114)  bm1[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C115)  a133:q3*d1q3+ev1$
(C116)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C117)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C118)  bm1[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C119)  a134:q3*d1q4$
(C120)  a434:ev4ay*drcq4+coe1*d4q4$
(C121)  a534:-ev5ay*drcq4+coe*d5q4$
(C122)  bm1[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C123)  a135:q3*d1q5$
(C124)  a435:ev4ay*drcq5+coe1*d4q5$
(C125)  a535:-ev5ay*drcq5+coe*d5q5$
(C126)  bm1[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C127)  rcazt:rc*azt$
(C128)  ev4az:ev4*azt$
(C129)  ev5az:ev5*azt$
(C130)  coe1:q4+rcazt$
(C131)  coe:q4-rcazt$
(C132)  a141:q4*d1q1$
(C133)  a441:ev4az*drcq1+coe1*d4q1$
(C134)  a541:-ev5az*drcq1+coe*d5q1$
(C135)  bm1[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C136)  a142:q4*d1q2$
(C137)  a442:ev4az*drcq2+coe1*d4q2$
(C138)  a542:-ev5az*drcq2+coe*d5q2$
(C139)  bm1[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C140)  a143:q4*d1q3$
(C141)  a443:ev4az*drcq3+coe1*d4q3$
(C142)  a543:-ev5az*drcq3+coe*d5q3$
(C143)  bm1[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C144)  a144:q4*d1q4+ev1$
(C145)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C146)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C147)  bm1[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C148)  a145:q4*d1q5$
(C149)  a445:ev4az*drcq5+coe1*d4q5$
(C150)  a545:-ev5az*drcq5+coe*d5q5$
(C151)  bm1[4,5]:cg1*a145+cg2*a445+cg3*a545$
```

```
(C152)  rctt:rc*tt$
(C153)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C154)  rt:rc*dttq1+tt*drcq1$
(C155)  a151:2*coe*d1q1$
(C156)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C157)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C158)  bm1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C159)  rt:rc*dttq2+tt*drcq2$
(C160)  a152:coe*d1q2-d1q1*q2$
(C161)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C162)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C163)  bm1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C164)  rt:rc*dttq3+tt*drcq3$
(C165)  a153:coe*d1q3-d1q1*q3$
(C166)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C167)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C168)  bm1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C169)  rt:rc*dttq4+tt*drcq4$
(C170)  a154:coe*d1q4-d1q1*q4$
(C171)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C172)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C173)  bm1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C174)  rt:tt*drcq5$
(C175)  a155:coe*d1q5$
(C176)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C177)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C178)  bm1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C179)  q1:q1$
(C180)  q2:q2$
(C181)  q3:q3$
(C182)  q4:-q4$
(C183)  q5:q5$
(C184)  sign:1$
(C185)  etz:-etz;
(C186)  cgg1:(gam-1)/gam$
(C187)  cgg2:1/(2*gam)$
(C188)  sada:sqrt(etx**2+ety**2+etz**2)$
(C189)  axt:etx/sada$
(C190)  ayt:ety/sada$
(C191)  azt:etz/sada$
(C192)  rqrq:q2**2+q3**2+q4**2$
(C193)  q6:1/q1$
(C194)  pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195)  prgam:pr*gam$
(C196)  pp:q5+pr$
(C197)  c:sqrt(prgam*q6)$
(C198)  tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199)  rc:q1*c$
(C200)  csad:c*sada$
(C201)  e1:tt*sada$
(C202)  e4:e1+csad$
```

```
(C203)  e5:e1-csad$
(C204)  ev1:0.0$
(C205)  ev4:0.0$
(C206)  ev5:0.0$
(C207)  cg1:0.0$
(C208)  cg2:0.0$
(C209)  cg3:0.0$
(C210)  d1q1:-ev1*q6$
(C211)  d1q2:etx*q6$
(C212)  d1q3:ety*q6$
(C213)  d1q4:etz*q6$
(C214)  d1q5:0.0$
(C215)  coe:gam*(gam-1)/(2*rc)$
(C216)  gm1q6:(gam-1)*q6$
(C217)  drcq1:coe*q5$
(C218)  drcq2:-coe*q2$
(C219)  drcq3:-coe*q3$
(C220)  drcq4:-coe*q4$
(C221)  drcq5:coe*q1$
(C222)  dcq1:(drcq1-c)*q6$
(C223)  dcq2:drcq2*q6$
(C224)  dcq3:drcq3*q6$
(C225)  dcq4:drcq4*q6$
(C226)  dcq5:drcq5*q6$
(C227)  depq1:0.5*gm1q6*rqrq*q6$
(C228)  depq2:-q2*gm1q6$
(C229)  depq3:-q3*gm1q6$
(C230)  depq4:-q4*gm1q6$
(C231)  depq5:gam$
(C232)  dttq1:-tt*q6$
(C233)  dttq2:axt*q6$
(C234)  dttq3:ayt*q6$
(C235)  dttq4:azt*q6$
(C236)  dttq5:0.0$
(C237)  d4q1:sada*(dttq1+dcq1)$
(C238)  d4q2:sada*(dttq2+dcq2)$
(C239)  d4q3:sada*(dttq3+dcq3)$
(C240)  d4q4:sada*(dttq4+dcq4)$
(C241)  d4q5:sada*dcq5$
(C242)  d5q1:sada*(dttq1-dcq1)$
(C243)  d5q2:sada*(dttq2-dcq2)$
(C244)  d5q3:sada*(dttq3-dcq3)$
(C245)  d5q4:sada*(dttq4-dcq4)$
(C246)  d5q5:-d4q5$
(C247)  a411:ev4+q1*d4q1$
(C248)  a511:ev5+q1*d5q1$
(C249)  bm2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C250)  bm2[1,1]:cg2*a411+cg3*a511$
(C251)  bm2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C252)  bm2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
```

```
(C253)  bm2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C254)  bm2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C255)  rcaxt:rc*axt$
(C256)  ev4ax:ev4*axt$
(C257)  ev5ax:ev5*axt$
(C258)  coe1:q2+rcaxt$
(C259)  coe:q2-rcaxt$
(C260)  a121:q2*d1q1$
(C261)  a421:ev4ax*drcq1+coe1*d4q1$
(C262)  a521:-ev5ax*drcq1+coe*d5q1$
(C263)  bm2[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C264)  a122:q2*d1q2+ev1$
(C265)  a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C266)  a522:ev5-ev5ax*drcq2+coe*d5q2$
(C267)  bm2[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C268)  a123:q2*d1q3$
(C269)  a423:ev4ax*drcq3+coe1*d4q3$
(C270)  a523:-ev5ax*drcq3+coe*d5q3$
(C271)  bm2[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C272)  a124:q2*d1q4$
(C273)  a424:ev4ax*drcq4+coe1*d4q4$
(C274)  a524:-ev5ax*drcq4+coe*d5q4$
(C275)  bm2[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C276)  a125:q2*d1q5$
(C277)  a425:ev4ax*drcq5+coe1*d4q5$
(C278)  a525:-ev5ax*drcq5+coe*d5q5$
(C279)  bm2[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C280)  rcayt:rc*ayt$
(C281)  ev4ay:ev4*ayt$
(C282)  ev5ay:ev5*ayt$
(C283)  coe1:q3+rcayt$
(C284)  coe:q3-rcayt$
(C285)  a131:q3*d1q1$
(C286)  a431:ev4ay*drcq1+coe1*d4q1$
(C287)  a531:-ev5ay*drcq1+coe*d5q1$
(C288)  bm2[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C289)  a132:q3*d1q2$
(C290)  a432:ev4ay*drcq2+coe1*d4q2$
(C291)  a532:-ev5ay*drcq2+coe*d5q2$
(C292)  bm2[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C293)  a133:q3*d1q3+ev1$
(C294)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C295)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C296)  bm2[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C297)  a134:q3*d1q4$
(C298)  a434:ev4ay*drcq4+coe1*d4q4$
(C299)  a534:-ev5ay*drcq4+coe*d5q4$
(C300)  bm2[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C301)  a135:q3*d1q5$
(C302)  a435:ev4ay*drcq5+coe1*d4q5$
(C303)  a535:-ev5ay*drcq5+coe*d5q5$
```

```
(C304)  bm2[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C305)  rcazt:rc*azt$
(C306)  ev4az:ev4*azt$
(C307)  ev5az:ev5*azt$
(C308)  coe1:q4+rcazt$
(C309)  coe:q4-rcazt$
(C310)  a141:q4*d1q1$
(C311)  a441:ev4az*drcq1+coe1*d4q1$
(C312)  a541:-ev5az*drcq1+coe*d5q1$
(C313)  bm2[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C314)  a142:q4*d1q2$
(C315)  a442:ev4az*drcq2+coe1*d4q2$
(C316)  a542:-ev5az*drcq2+coe*d5q2$
(C317)  bm2[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C318)  a143:q4*d1q3$
(C319)  a443:ev4az*drcq3+coe1*d4q3$
(C320)  a543:-ev5az*drcq3+coe*d5q3$
(C321)  bm2[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C322)  a144:q4*d1q4+ev1$
(C323)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C324)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C325)  bm2[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C326)  a145:q4*d1q5$
(C327)  a445:ev4az*drcq5+coe1*d4q5$
(C328)  a545:-ev5az*drcq5+coe*d5q5$
(C329)  bm2[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C330)  rctt:rc*tt$
(C331)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C332)  rt:rc*dttq1+tt*drcq1$
(C333)  a151:2*coe*d1q1$
(C334)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C335)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C336)  bm2[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C337)  rt:rc*dttq2+tt*drcq2$
(C338)  a152:coe*d1q2-d1q1*q2$
(C339)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C340)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C341)  bm2[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C342)  rt:rc*dttq3+tt*drcq3$
(C343)  a153:coe*d1q3-d1q1*q3$
(C344)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C345)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C346)  bm2[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C347)  rt:rc*dttq4+tt*drcq4$
(C348)  a154:coe*d1q4-d1q1*q4$
(C349)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C350)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C351)  bm2[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C352)  rt:tt*drcq5$
(C353)  a155:coe*d1q5$
(C354)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
```

```
(C355)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C356)  bm2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C357)  diff:bm1.m-m.bm2$
(C358)  diff:ratexpand(diff);
```

$$
\begin{bmatrix}
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0
\end{bmatrix}
$$

(D358)

```
(C359)  closefile(Bmsup)$
```

```
(C3)  bm1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4)  bm2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5)  m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C6)  diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C7)  sign:-1$
(C8)  cgg1:(gam-1)/gam$
(C9)  cgg2:1/(2*gam)$
(C10)  etx:0.0$
(C11)  sada:sqrt(etx**2+ety**2+etz**2)$
(C12)  axt:etx/sada$
(C13)  ayt:ety/sada$
(C14)  azt:etz/sada$
(C15)  rqrq:q2**2+q3**2+q4**2$
(C16)  q6:1/q1$
(C17)  pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C18)  prgam:pr*gam$
(C19)  pp:q5+pr$
(C20)  c:sqrt(prgam*q6)$
(C21)  tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C22)  rc:q1*c$
(C23)  csad:c*sada$
(C24)  e1:tt*sada$
(C25)  e4:e1+csad$
(C26)  e5:e1-csad$
(C27)  ev1:0.0$
(C28)  ev4:0.0$
(C29)  ev5:0.5*(e5+sign*abs(e5))$
(C30)  cg1:0.0$
(C31)  cg2:0.0$
(C32)  cg3:cgg2$
(C33)  d1q1:-ev1*q6$
(C34)  d1q2:etx*q6$
(C35)  d1q3:ety*q6$
(C36)  d1q4:etz*q6$
(C37)  d1q5:0.0$
(C38)  coe:gam*(gam-1)/(2*rc)$
(C39)  gm1q6:(gam-1)*q6$
(C40)  drcq1:coe*q5$
(C41)  drcq2:-coe*q2$
(C42)  drcq3:-coe*q3$
(C43)  drcq4:-coe*q4$
(C44)  drcq5:coe*q1$
(C45)  dcq1:(drcq1-c)*q6$
(C46)  dcq2:drcq2*q6$
(C47)  dcq3:drcq3*q6$
(C48)  dcq4:drcq4*q6$
(C49)  dcq5:drcq5*q6$
```

```
(C50)   depq1:0.5*gm1q6*rqrq*q6$
(C51)   depq2:-q2*gm1q6$
(C52)   depq3:-q3*gm1q6$
(C53)   depq4:-q4*gm1q6$
(C54)   depq5:gam$
(C55)   dttq1:-tt*q6$
(C56)   dttq2:axt*q6$
(C57)   dttq3:ayt*q6$
(C58)   dttq4:azt*q6$
(C59)   dttq5:0.0$
(C60)   d4q1:sada*(dttq1+dcq1)$
(C61)   d4q2:sada*(dttq2+dcq2)$
(C62)   d4q3:sada*(dttq3+dcq3)$
(C63)   d4q4:sada*(dttq4+dcq4)$
(C64)   d4q5:sada*dcq5$
(C65)   d5q1:sada*(dttq1-dcq1)$
(C66)   d5q2:sada*(dttq2-dcq2)$
(C67)   d5q3:sada*(dttq3-dcq3)$
(C68)   d5q4:sada*(dttq4-dcq4)$
(C69)   d5q5:-d4q5$
(C70)   a411:ev4+q1*d4q1$
(C71)   a511:ev5+q1*d5q1$
(C72)   bm1[1,1]:cg2*a411+cg3*a511$
(C73)   bm1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C74)   bm1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C75)   bm1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C76)   bm1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C77)   rcaxt:rc*axt$
(C78)   ev4ax:ev4*axt$
(C79)   ev5ax:ev5*axt$
(C80)   coe1:q2+rcaxt$
(C81)   coe:q2-rcaxt$
(C82)   a121:q2*d1q1$
(C83)   a421:ev4ax*drcq1+coe1*d4q1$
(C84)   a521:-ev5ax*drcq1+coe*d5q1$
(C85)   bm1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C86)   a122:q2*d1q2+ev1$
(C87)   a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C88)   a522:ev5-ev5ax*drcq2+coe*d5q2$
(C89)   bm1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C90)   a123:q2*d1q3$
(C91)   a423:ev4ax*drcq3+coe1*d4q3$
(C92)   a523:-ev5ax*drcq3+coe*d5q3$
(C93)   bm1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C94)   a124:q2*d1q4$
(C95)   a424:ev4ax*drcq4+coe1*d4q4$
(C96)   a524:-ev5ax*drcq4+coe*d5q4$
(C97)   bm1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C98)   a125:q2*d1q5$
(C99)   a425:ev4ax*drcq5+coe1*d4q5$
(C100)  a525:-ev5ax*drcq5+coe*d5q5$
```

```
(C101)  bm1[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C102)  rcayt:rc*ayt$
(C103)  ev4ay:ev4*ayt$
(C104)  ev5ay:ev5*ayt$
(C105)  coe1:q3+rcayt$
(C106)  coe:q3-rcayt$
(C107)  a131:q3*d1q1$
(C108)  a431:ev4ay*drcq1+coe1*d4q1$
(C109)  a531:-ev5ay*drcq1+coe*d5q1$
(C110)  bm1[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C111)  a132:q3*d1q2$
(C112)  a432:ev4ay*drcq2+coe1*d4q2$
(C113)  a532:-ev5ay*drcq2+coe*d5q2$
(C114)  bm1[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C115)  a133:q3*d1q3+ev1$
(C116)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C117)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C118)  bm1[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C119)  a134:q3*d1q4$
(C120)  a434:ev4ay*drcq4+coe1*d4q4$
(C121)  a534:-ev5ay*drcq4+coe*d5q4$
(C122)  bm1[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C123)  a135:q3*d1q5$
(C124)  a435:ev4ay*drcq5+coe1*d4q5$
(C125)  a535:-ev5ay*drcq5+coe*d5q5$
(C126)  bm1[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C127)  rcazt:rc*azt$
(C128)  ev4az:ev4*azt$
(C129)  ev5az:ev5*azt$
(C130)  coe1:q4+rcazt$
(C131)  coe:q4-rcazt$
(C132)  a141:q4*d1q1$
(C133)  a441:ev4az*drcq1+coe1*d4q1$
(C134)  a541:-ev5az*drcq1+coe*d5q1$
(C135)  bm1[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C136)  a142:q4*d1q2$
(C137)  a442:ev4az*drcq2+coe1*d4q2$
(C138)  a542:-ev5az*drcq2+coe*d5q2$
(C139)  bm1[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C140)  a143:q4*d1q3$
(C141)  a443:ev4az*drcq3+coe1*d4q3$
(C142)  a543:-ev5az*drcq3+coe*d5q3$
(C143)  bm1[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C144)  a144:q4*d1q4+ev1$
(C145)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C146)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C147)  bm1[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C148)  a145:q4*d1q5$
(C149)  a445:ev4az*drcq5+coe1*d4q5$
(C150)  a545:-ev5az*drcq5+coe*d5q5$
(C151)  bm1[4,5]:cg1*a145+cg2*a445+cg3*a545$
```

```
(C152)  rctt:rc*tt$
(C153)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C154)  rt:rc*dttq1+tt*drcq1$
(C155)  a151:2*coe*d1q1$
(C156)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C157)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C158)  bm1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C159)  rt:rc*dttq2+tt*drcq2$
(C160)  a152:coe*d1q2-d1q1*q2$
(C161)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C162)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C163)  bm1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C164)  rt:rc*dttq3+tt*drcq3$
(C165)  a153:coe*d1q3-d1q1*q3$
(C166)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C167)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C168)  bm1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C169)  rt:rc*dttq4+tt*drcq4$
(C170)  a154:coe*d1q4-d1q1*q4$
(C171)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C172)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C173)  bm1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C174)  rt:tt*drcq5$
(C175)  a155:coe*d1q5$
(C176)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C177)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C178)  bm1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C179)  q1:q1$
(C180)  q2:q2$
(C181)  q3:q3$
(C182)  q4:-q4$
(C183)  q5:q5$
(C184)  etz:-etz;
(C185)  cgg1:(gam-1)/gam$
(C186)  cgg2:1/(2*gam)$
(C187)  sada:sqrt(etx**2+ety**2+etz**2)$
(C188)  axt:etx/sada$
(C189)  ayt:ety/sada$
(C190)  azt:etz/sada$
(C191)  rqrq:q2**2+q3**2+q4**2$
(C192)  q6:1/q1$
(C193)  pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C194)  prgam:pr*gam$
(C195)  pp:q5+pr$
(C196)  c:sqrt(prgam*q6)$
(C197)  tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C198)  rc:q1*c$
(C199)  csad:c*sada$
(C200)  e1:tt*sada$
(C201)  e4:e1+csad$
(C202)  e5:e1-csad$
```

```
(C203)   ev1:0.0$
(C204)   ev4:0.0$
(C205)   ev5:0.5*(e5+sign*abs(e5))$
(C206)   cg1:0.0$
(C207)   cg2:0.0$
(C208)   cg3:cgg2$
(C209)   d1q1:-ev1*q6$
(C210)   d1q2:etx*q6$
(C211)   d1q3:ety*q6$
(C212)   d1q4:etz*q6$
(C213)   d1q5:0.0$
(C214)   coe:gam*(gam-1)/(2*rc)$
(C215)   gm1q6:(gam-1)*q6$
(C216)   drcq1:coe*q5$
(C217)   drcq2:-coe*q2$
(C218)   drcq3:-coe*q3$
(C219)   drcq4:-coe*q4$
(C220)   drcq5:coe*q1$
(C221)   dcq1:(drcq1-c)*q6$
(C222)   dcq2:drcq2*q6$
(C223)   dcq3:drcq3*q6$
(C224)   dcq4:drcq4*q6$
(C225)   dcq5:drcq5*q6$
(C226)   depq1:0.5*gm1q6*rqrq*q6$
(C227)   depq2:-q2*gm1q6$
(C228)   depq3:-q3*gm1q6$
(C229)   depq4:-q4*gm1q6$
(C230)   depq5:gam$
(C231)   dttq1:-tt*q6$
(C232)   dttq2:axt*q6$
(C233)   dttq3:ayt*q6$
(C234)   dttq4:azt*q6$
(C235)   dttq5:0.0$
(C236)   d4q1:sada*(dttq1+dcq1)$
(C237)   d4q2:sada*(dttq2+dcq2)$
(C238)   d4q3:sada*(dttq3+dcq3)$
(C239)   d4q4:sada*(dttq4+dcq4)$
(C240)   d4q5:sada*dcq5$
(C241)   d5q1:sada*(dttq1-dcq1)$
(C242)   d5q2:sada*(dttq2-dcq2)$
(C243)   d5q3:sada*(dttq3-dcq3)$
(C244)   d5q4:sada*(dttq4-dcq4)$
(C245)   d5q5:-d4q5$
(C246)   a411:ev4+q1*d4q1$
(C247)   a511:ev5+q1*d5q1$
(C248)   bm2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C249)   bm2[1,1]:cg2*a411+cg3*a511$
(C250)   bm2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C251)   bm2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C252)   bm2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
```

```
(C253)  bm2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C254)  rcaxt:rc*axt$
(C255)  ev4ax:ev4*axt$
(C256)  ev5ax:ev5*axt$
(C257)  coe1:q2+rcaxt$
(C258)  coe:q2-rcaxt$
(C259)  a121:q2*d1q1$
(C260)  a421:ev4ax*drcq1+coe1*d4q1$
(C261)  a521:-ev5ax*drcq1+coe*d5q1$
(C262)  bm2[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C263)  a122:q2*d1q2+ev1$
(C264)  a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C265)  a522:ev5-ev5ax*drcq2+coe*d5q2$
(C266)  bm2[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C267)  a123:q2*d1q3$
(C268)  a423:ev4ax*drcq3+coe1*d4q3$
(C269)  a523:-ev5ax*drcq3+coe*d5q3$
(C270)  bm2[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C271)  a124:q2*d1q4$
(C272)  a424:ev4ax*drcq4+coe1*d4q4$
(C273)  a524:-ev5ax*drcq4+coe*d5q4$
(C274)  bm2[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C275)  a125:q2*d1q5$
(C276)  a425:ev4ax*drcq5+coe1*d4q5$
(C277)  a525:-ev5ax*drcq5+coe*d5q5$
(C278)  bm2[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C279)  rcayt:rc*ayt$
(C280)  ev4ay:ev4*ayt$
(C281)  ev5ay:ev5*ayt$
(C282)  coe1:q3+rcayt$
(C283)  coe:q3-rcayt$
(C284)  a131:q3*d1q1$
(C285)  a431:ev4ay*drcq1+coe1*d4q1$
(C286)  a531:-ev5ay*drcq1+coe*d5q1$
(C287)  bm2[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C288)  a132:q3*d1q2$
(C289)  a432:ev4ay*drcq2+coe1*d4q2$
(C290)  a532:-ev5ay*drcq2+coe*d5q2$
(C291)  bm2[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C292)  a133:q3*d1q3+ev1$
(C293)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C294)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C295)  bm2[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C296)  a134:q3*d1q4$
(C297)  a434:ev4ay*drcq4+coe1*d4q4$
(C298)  a534:-ev5ay*drcq4+coe*d5q4$
(C299)  bm2[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C300)  a135:q3*d1q5$
(C301)  a435:ev4ay*drcq5+coe1*d4q5$
(C302)  a535:-ev5ay*drcq5+coe*d5q5$
(C303)  bm2[3,5]:cg1*a135+cg2*a435+cg3*a535$
```

```
(C304)  rcazt:rc*azt$
(C305)  ev4az:ev4*azt$
(C306)  ev5az:ev5*azt$
(C307)  coe1:q4+rcazt$
(C308)  coe:q4-rcazt$
(C309)  a141:q4*d1q1$
(C310)  a441:ev4az*drcq1+coe1*d4q1$
(C311)  a541:-ev5az*drcq1+coe*d5q1$
(C312)  bm2[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C313)  a142:q4*d1q2$
(C314)  a442:ev4az*drcq2+coe1*d4q2$
(C315)  a542:-ev5az*drcq2+coe*d5q2$
(C316)  bm2[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C317)  a143:q4*d1q3$
(C318)  a443:ev4az*drcq3+coe1*d4q3$
(C319)  a543:-ev5az*drcq3+coe*d5q3$
(C320)  bm2[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C321)  a144:q4*d1q4+ev1$
(C322)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C323)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C324)  bm2[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C325)  a145:q4*d1q5$
(C326)  a445:ev4az*drcq5+coe1*d4q5$
(C327)  a545:-ev5az*drcq5+coe*d5q5$
(C328)  bm2[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C329)  rctt:rc*tt$
(C330)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C331)  rt:rc*dttq1+tt*drcq1$
(C332)  a151:2*coe*d1q1$
(C333)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C334)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C335)  bm2[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C336)  rt:rc*dttq2+tt*drcq2$
(C337)  a152:coe*d1q2-d1q1*q2$
(C338)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C339)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C340)  bm2[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C341)  rt:rc*dttq3+tt*drcq3$
(C342)  a153:coe*d1q3-d1q1*q3$
(C343)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C344)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C345)  bm2[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C346)  rt:rc*dttq4+tt*drcq4$
(C347)  a154:coe*d1q4-d1q1*q4$
(C348)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C349)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C350)  bm2[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C351)  rt:tt*drcq5$
(C352)  a155:coe*d1q5$
(C353)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C354)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
```

```
(C355)  bm2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C356)  diff:bm1.m-m.bm2$
(C357)  diff:ratexpand(diff);
```

(D357)

$$
\begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}
$$

```
(C358)  closefile(Bmsub)$
```

```
(C3)  cp:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,
0,0,0,0])$
(C4)  cm:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,
0,0,0,0])$
(C5)  diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C6)  m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C7)  sign:1$
(C8)  cgg1:(gam-1)/gam$
(C9)  cgg2:1/(2*gam)$
(C10)  sada:sqrt(ztx**2+zty**2+ztz**2)$
(C11)  axt:ztx/sada$
(C12)  ayt:zty/sada$
(C13)  azt:ztz/sada$
(C14)  rqrq:q2**2+q3**2+q4**2$
(C15)  q6:1/q1$
(C16)  pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C17)  prgam:pr*gam$
(C18)  pp:q5+pr$
(C19)  c:sqrt(prgam*q6)$
(C20)  tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C21)  rc:q1*c$
(C22)  csad:c*sada$
(C23)  e1:tt*sada$
(C24)  e4:e1+csad$
(C25)  e5:e1-csad$
(C26)  ev1:e1$
(C27)  ev4:e4$
(C28)  ev5:e1$
(C29)  cg1:cgg1$
(C30)  cg2:cgg2$
(C31)  cg3:cgg2$
(C32)  d1q1:-ev1*q6$
(C33)  d1q2:ztx*q6$
(C34)  d1q3:zty*q6$
(C35)  d1q4:ztz*q6$
(C36)  d1q5:0.0$
(C37)  coe:gam*(gam-1)/(2*rc)$
(C38)  gm1q6:(gam-1)*q6$
(C39)  drcq1:coe*q5$
(C40)  drcq2:-coe*q2$
(C41)  drcq3:-coe*q3$
(C42)  drcq4:-coe*q4$
(C43)  drcq5:coe*q1$
(C44)  dcq1:(drcq1-c)*q6$
(C45)  dcq2:drcq2*q6$
(C46)  dcq3:drcq3*q6$
(C47)  dcq4:drcq4*q6$
(C48)  dcq5:drcq5*q6$
(C49)  depq1:0.5*gm1q6*rqrq*q6$
```

```
(C50)  depq2:-q2*gm1q6$
(C51)  depq3:-q3*gm1q6$
(C52)  depq4:-q4*gm1q6$
(C53)  depq5:gam$
(C54)  dttq1:-tt*q6$
(C55)  dttq2:axt*q6$
(C56)  dttq3:ayt*q6$
(C57)  dttq4:azt*q6$
(C58)  dttq5:0.0$
(C59)  d4q1:sada*(dttq1+dcq1)$
(C60)  d4q2:sada*(dttq2+dcq2)$
(C61)  d4q3:sada*(dttq3+dcq3)$
(C62)  d4q4:sada*(dttq4+dcq4)$
(C63)  d4q5:sada*dcq5$
(C64)  d5q1:sada*(dttq1-dcq1)$
(C65)  d5q2:sada*(dttq2-dcq2)$
(C66)  d5q3:sada*(dttq3-dcq3)$
(C67)  d5q4:sada*(dttq4-dcq4)$
(C68)  d5q5:-d4q5$
(C69)  a411:ev4+q1*d4q1$
(C70)  a511:ev5+q1*d5q1$
(C71)  cp[1,1]:cg2*a411+cg3*a511$
(C72)  cp[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C73)  cp[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C74)  cp[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C75)  cp[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C76)  rcaxt:rc*axt$
(C77)  ev4ax:ev4*axt$
(C78)  ev5ax:ev5*axt$
(C79)  coe1:q2+rcaxt$
(C80)  coe:q2-rcaxt$
(C81)  a121:q2*d1q1$
(C82)  a421:ev4ax*drcq1+coe1*d4q1$
(C83)  a521:-ev5ax*drcq1+coe*d5q1$
(C84)  cp[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C85)  a122:q2*d1q2+ev1$
(C86)  a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C87)  a522:ev5-ev5ax*drcq2+coe*d5q2$
(C88)  cp[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C89)  a123:q2*d1q3$
(C90)  a423:ev4ax*drcq3+coe1*d4q3$
(C91)  a523:-ev5ax*drcq3+coe*d5q3$
(C92)  cp[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C93)  a124:q2*d1q4$
(C94)  a424:ev4ax*drcq4+coe1*d4q4$
(C95)  a524:-ev5ax*drcq4+coe*d5q4$
(C96)  cp[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C97)  a125:q2*d1q5$
(C98)  a425:ev4ax*drcq5+coe1*d4q5$
(C99)  a525:-ev5ax*drcq5+coe*d5q5$
(C100) cp[2,5]:cg1*a125+cg2*a425+cg3*a525$
```

```
(C101)   rcayt:rc*ayt$
(C102)   ev4ay:ev4*ayt$
(C103)   ev5ay:ev5*ayt$
(C104)   coe1:q3+rcayt$
(C105)   coe:q3-rcayt$
(C106)   a131:q3*d1q1$
(C107)   a431:ev4ay*drcq1+coe1*d4q1$
(C108)   a531:-ev5ay*drcq1+coe*d5q1$
(C109)   cp[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C110)   a132:q3*d1q2$
(C111)   a432:ev4ay*drcq2+coe1*d4q2$
(C112)   a532:-ev5ay*drcq2+coe*d5q2$
(C113)   cp[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C114)   a133:q3*d1q3+ev1$
(C115)   a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C116)   a533:ev5-ev5ay*drcq3+coe*d5q3$
(C117)   cp[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C118)   a134:q3*d1q4$
(C119)   a434:ev4ay*drcq4+coe1*d4q4$
(C120)   a534:-ev5ay*drcq4+coe*d5q4$
(C121)   cp[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C122)   a135:q3*d1q5$
(C123)   a435:ev4ay*drcq5+coe1*d4q5$
(C124)   a535:-ev5ay*drcq5+coe*d5q5$
(C125)   cp[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C126)   rcazt:rc*azt$
(C127)   ev4az:ev4*azt$
(C128)   ev5az:ev5*azt$
(C129)   coe1:q4+rcazt$
(C130)   coe:q4-rcazt$
(C131)   a141:q4*d1q1$
(C132)   a441:ev4az*drcq1+coe1*d4q1$
(C133)   a541:-ev5az*drcq1+coe*d5q1$
(C134)   cp[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C135)   a142:q4*d1q2$
(C136)   a442:ev4az*drcq2+coe1*d4q2$
(C137)   a542:-ev5az*drcq2+coe*d5q2$
(C138)   cp[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C139)   a143:q4*d1q3$
(C140)   a443:ev4az*drcq3+coe1*d4q3$
(C141)   a543:-ev5az*drcq3+coe*d5q3$
(C142)   cp[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C143)   a144:q4*d1q4+ev1$
(C144)   a444:ev4+ev4az*drcq4+coe1*d4q4$
(C145)   a544:ev5-ev5az*drcq4+coe*d5q4$
(C146)   cp[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C147)   a145:q4*d1q5$
(C148)   a445:ev4az*drcq5+coe1*d4q5$
(C149)   a545:-ev5az*drcq5+coe*d5q5$
(C150)   cp[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C151)   rctt:rc*tt$
```

```
(C152)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C153)  rt:rc*dttq1+tt*drcq1$
(C154)  a151:2*coe*d1q1$
(C155)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C156)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C157)  cp[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C158)  rt:rc*dttq2+tt*drcq2$
(C159)  a152:coe*d1q2-d1q1*q2$
(C160)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C161)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C162)  cp[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C163)  rt:rc*dttq3+tt*drcq3$
(C164)  a153:coe*d1q3-d1q1*q3$
(C165)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C166)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C167)  cp[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C168)  rt:rc*dttq4+tt*drcq4$
(C169)  a154:coe*d1q4-d1q1*q4$
(C170)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C171)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C172)  cp[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C173)  rt:tt*drcq5$
(C174)  a155:coe*d1q5$
(C175)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C176)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C177)  cp[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C178)  q1:q1$
(C179)  q2:q2$
(C180)  q3:q3$
(C181)  q4:-q4$
(C182)  q5:q5$
(C183)  ztx:-ztx$
(C184)  zty:-zty$
(C185)  sign:-1$
(C186)  cgg1:(gam-1)/gam$
(C187)  cgg2:1/(2*gam)$
(C188)  sada:sqrt(ztx**2+zty**2+ztz**2)$
(C189)  axt:ztx/sada$
(C190)  ayt:zty/sada$
(C191)  azt:ztz/sada$
(C192)  rqrq:q2**2+q3**2+q4**2$
(C193)  q6:1/q1$
(C194)  pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195)  prgam:pr*gam$
(C196)  pp:q5+pr$
(C197)  c:sqrt(prgam*q6)$
(C198)  tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199)  rc:q1*c$
(C200)  csad:c*sada$
(C201)  e1:tt*sada$
(C202)  e4:e1+csad$
```

```
(C203)  e5:e1-csad$
(C204)  ev1:e1$
(C205)  ev4:e1$
(C206)  ev5:e5$
(C209)  cg1:cgg1$
(C208)  cg2:cgg2$
(C209)  cg3:cgg2$
(C210)  d1q1:-ev1*q6$
(C211)  d1q2:ztx*q6$
(C212)  d1q3:zty*q6$
(C213)  d1q4:ztz*q6$
(C214)  d1q5:0.0$
(C215)  coe:gam*(gam-1)/(2*rc)$
(C216)  gm1q6:(gam-1)*q6$
(C217)  drcq1:coe*q5$
(C218)  drcq2:-coe*q2$
(C219)  drcq3:-coe*q3$
(C220)  drcq4:-coe*q4$
(C221)  drcq5:coe*q1$
(C222)  dcq1:(drcq1-c)*q6$
(C223)  dcq2:drcq2*q6$
(C224)  dcq3:drcq3*q6$
(C225)  dcq4:drcq4*q6$
(C226)  dcq5:drcq5*q6$
(C227)  depq1:0.5*gm1q6*rqrq*q6$
(C228)  depq2:-q2*gm1q6$
(C229)  depq3:-q3*gm1q6$
(C230)  depq4:-q4*gm1q6$
(C231)  depq5:gam$
(C232)  dttq1:-tt*q6$
(C233)  dttq2:axt*q6$
(C234)  dttq3:ayt*q6$
(C235)  dttq4:azt*q6$
(C236)  dttq5:0.0$
(C237)  d4q1:sada*(dttq1+dcq1)$
(C238)  d4q2:sada*(dttq2+dcq2)$
(C239)  d4q3:sada*(dttq3+dcq3)$
(C240)  d4q4:sada*(dttq4+dcq4)$
(C241)  d4q5:sada*dcq5$
(C242)  d5q1:sada*(dttq1-dcq1)$
(C243)  d5q2:sada*(dttq2-dcq2)$
(C244)  d5q3:sada*(dttq3-dcq3)$
(C245)  d5q4:sada*(dttq4-dcq4)$
(C246)  d5q5:-d4q5$
(C247)  a411:ev4+q1*d4q1$
(C248)  a511:ev5+q1*d5q1$
(C249)  cm[1,1]:cg2*a411+cg3*a511$
(C250)  cm[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C251)  cm[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C252)  cm[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C253)  cm[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
```

```
(C254)  rcaxt:rc*axt$
(C255)  ev4ax:ev4*axt$
(C256)  ev5ax:ev5*axt$
(C257)  coe1:q2+rcaxt$
(C258)  coe:q2-rcaxt$
(C259)  a121:q2*d1q1$
(C260)  a421:ev4ax*drcq1+coe1*d4q1$
(C261)  a521:-ev5ax*drcq1+coe*d5q1$
(C262)  cm[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C263)  a122:q2*d1q2+ev1$
(C264)  a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C265)  a522:ev5-ev5ax*drcq2+coe*d5q2$
(C266)  cm[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C267)  a123:q2*d1q3$
(C268)  a423:ev4ax*drcq3+coe1*d4q3$
(C269)  a523:-ev5ax*drcq3+coe*d5q3$
(C270)  cm[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C271)  a124:q2*d1q4$
(C272)  a424:ev4ax*drcq4+coe1*d4q4$
(C273)  a524:-ev5ax*drcq4+coe*d5q4$
(C274)  cm[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C275)  a125:q2*d1q5$
(C276)  a425:ev4ax*drcq5+coe1*d4q5$
(C277)  a525:-ev5ax*drcq5+coe*d5q5$
(C278)  cm[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C279)  rcayt:rc*ayt$
(C280)  ev4ay:ev4*ayt$
(C281)  ev5ay:ev5*ayt$
(C282)  coe1:q3+rcayt$
(C283)  coe:q3-rcayt$
(C284)  a131:q3*d1q1$
(C285)  a431:ev4ay*drcq1+coe1*d4q1$
(C286)  a531:-ev5ay*drcq1+coe*d5q1$
(C287)  cm[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C288)  a132:q3*d1q2$
(C289)  a432:ev4ay*drcq2+coe1*d4q2$
(C290)  a532:-ev5ay*drcq2+coe*d5q2$
(C291)  cm[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C292)  a133:q3*d1q3+ev1$
(C293)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C294)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C295)  cm[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C296)  a134:q3*d1q4$
(C297)  a434:ev4ay*drcq4+coe1*d4q4$
(C298)  a534:-ev5ay*drcq4+coe*d5q4$
(C299)  cm[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C300)  a135:q3*d1q5$
(C301)  a435:ev4ay*drcq5+coe1*d4q5$
(C302)  a535:-ev5ay*drcq5+coe*d5q5$
(C303)  cm[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C304)  rcazt:rc*azt$
```

```
(C305)   ev4az:ev4*azt$
(C306)   ev5az:ev5*azt$
(C307)   coe1:q4+rcazt$
(C308)   coe:q4-rcazt$
(C309)   a141:q4*d1q1$
(C310)   a441:ev4az*drcq1+coe1*d4q1$
(C311)   a541:-ev5az*drcq1+coe*d5q1$
(C312)   cm[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C313)   a142:q4*d1q2$
(C314)   a442:ev4az*drcq2+coe1*d4q2$
(C315)   a542:-ev5az*drcq2+coe*d5q2$
(C316)   cm[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C317)   a143:q4*d1q3$
(C318)   a443:ev4az*drcq3+coe1*d4q3$
(C319)   a543:-ev5az*drcq3+coe*d5q3$
(C320)   cm[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C321)   a144:q4*d1q4+ev1$
(C322)   a444:ev4+ev4az*drcq4+coe1*d4q4$
(C323)   a544:ev5-ev5az*drcq4+coe*d5q4$
(C324)   cm[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C325)   a145:q4*d1q5$
(C326)   a445:ev4az*drcq5+coe1*d4q5$
(C327)   a545:-ev5az*drcq5+coe*d5q5$
(C328)   cm[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C329)   rctt:rc*tt$
(C330)   coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C331)   rt:rc*dttq1+tt*drcq1$
(C332)   a151:2*coe*d1q1$
(C333)   a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C334)   a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C335)   cm[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C336)   rt:rc*dttq2+tt*drcq2$
(C337)   a152:coe*d1q2-d1q1*q2$
(C338)   a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C339)   a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C340)   cm[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C341)   rt:rc*dttq3+tt*drcq3$
(C342)   a153:coe*d1q3-d1q1*q3$
(C343)   a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C344)   a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C346)   rt:rc*dttq4+tt*drcq4$
(C347)   a154:coe*d1q4-d1q1*q4$
(C348)   a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C349)   a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C350)   cm[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C351)   rt:tt*drcq5$
(C352)   a155:coe*d1q5$
(C353)   a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C354)   a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C355)   cm[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C356)   diff:cp.m+m.cm$
```

(C357) diff:ratexpand(diff);

```
                              [ 0   0   0   0   0 ]
                              [                   ]
                              [ 0   0   0   0   0 ]
                              [                   ]
(D357)                        [ 0   0   0   0   0 ]
                              [                   ]
                              [ 0   0   0   0   0 ]
                              [                   ]
                              [ 0   0   0   0   0 ]
```

(C358) closefile(Ccsup1)$

```
(C3)  cp:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,
0,0,0,0])$
(C4)  cm:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,
0,0,0,0])$
(C5)  diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C6)  m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C7)  sign:1$
(C8)  cgg1:(gam-1)/gam$
(C9)  cgg2:1/(2*gam)$
(C10)  sada:sqrt(ztx**2+zty**2+ztz**2)$
(C11)  axt:ztx/sada$
(C12)  ayt:zty/sada$
(C13)  azt:ztz/sada$
(C14)  rqrq:q2**2+q3**2+q4**2$
(C15)  q6:1/q1$
(C16)  pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C17)  prgam:pr*gam$
(C18)  pp:q5+pr$
(C19)  c:sqrt(prgam*q6)$
(C20)  tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C21)  rc:q1*c$
(C22)  csad:c*sada$
(C23)  e1:tt*sada$
(C24)  e4:e1+csad$
(C25)  e5:e1-csad$
(C26)  ev1:e1$
(C27)  ev4:e4$
(C28)  ev5:0.0$
(C29)  cg1:cgg1$
(C30)  cg2:cgg2$
(C31)  cg3:0.0$
(C32)  d1q1:-ev1*q6$
(C33)  d1q2:ztx*q6$
(C34)  d1q3:zty*q6$
(C35)  d1q4:ztz*q6$
(C36)  d1q5:0.0$
(C37)  coe:gam*(gam-1)/(2*rc)$
(C38)  gm1q6:(gam-1)*q6$
(C39)  drcq1:coe*q5$
(C40)  drcq2:-coe*q2$
(C41)  drcq3:-coe*q3$
(C42)  drcq4:-coe*q4$
(C43)  drcq5:coe*q1$
(C44)  dcq1:(drcq1-c)*q6$
(C45)  dcq2:drcq2*q6$
(C46)  dcq3:drcq3*q6$
(C47)  dcq4:drcq4*q6$
(C48)  dcq5:drcq5*q6$
(C49)  depq1:0.5*gm1q6*rqrq*q6$
```

```
(C50)   depq2:-q2*gm1q6$
(C51)   depq3:-q3*gm1q6$
(C52)   depq4:-q4*gm1q6$
(C53)   depq5:gam$
(C54)   dttq1:-tt*q6$
(C55)   dttq2:axt*q6$
(C56)   dttq3:ayt*q6$
(C57)   dttq4:azt*q6$
(C58)   dttq5:0.0$
(C59)   d4q1:sada*(dttq1+dcq1)$
(C60)   d4q2:sada*(dttq2+dcq2)$
(C61)   d4q3:sada*(dttq3+dcq3)$
(C62)   d4q4:sada*(dttq4+dcq4)$
(C63)   d4q5:sada*dcq5$
(C64)   d5q1:sada*(dttq1-dcq1)$
(C65)   d5q2:sada*(dttq2-dcq2)$
(C66)   d5q3:sada*(dttq3-dcq3)$
(C67)   d5q4:sada*(dttq4-dcq4)$
(C68)   d5q5:-d4q5$
(C69)   a411:ev4+q1*d4q1$
(C70)   a511:ev5+q1*d5q1$
(C71)   cp[1,1]:cg2*a411+cg3*a511$
(C72)   cp[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C73)   cp[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C74)   cp[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C75)   cp[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C76)   rcaxt:rc*axt$
(C77)   ev4ax:ev4*axt$
(C78)   ev5ax:ev5*axt$
(C79)   coe1:q2+rcaxt$
(C80)   coe:q2-rcaxt$
(C81)   a121:q2*d1q1$
(C82)   a421:ev4ax*drcq1+coe1*d4q1$
(C83)   a521:-ev5ax*drcq1+coe*d5q1$
(C84)   cp[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C85)   a122:q2*d1q2+ev1$
(C86)   a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C87)   a522:ev5-ev5ax*drcq2+coe*d5q2$
(C88)   cp[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C89)   a123:q2*d1q3$
(C90)   a423:ev4ax*drcq3+coe1*d4q3$
(C91)   a523:-ev5ax*drcq3+coe*d5q3$
(C92)   cp[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C93)   a124:q2*d1q4$
(C94)   a424:ev4ax*drcq4+coe1*d4q4$
(C95)   a524:-ev5ax*drcq4+coe*d5q4$
(C96)   cp[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C97)   a125:q2*d1q5$
(C98)   a425:ev4ax*drcq5+coe1*d4q5$
(C99)   a525:-ev5ax*drcq5+coe*d5q5$
(C100)  cp[2,5]:cg1*a125+cg2*a425+cg3*a525$
```

```
(C101)  rcayt:rc*ayt$
(C102)  ev4ay:ev4*ayt$
(C103)  ev5ay:ev5*ayt$
(C104)  coe1:q3+rcayt$
(C105)  coe:q3-rcayt$
(C106)  a131:q3*d1q1$
(C107)  a431:ev4ay*drcq1+coe1*d4q1$
(C108)  a531:-ev5ay*drcq1+coe*d5q1$
(C109)  cp[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C110)  a132:q3*d1q2$
(C111)  a432:ev4ay*drcq2+coe1*d4q2$
(C112)  a532:-ev5ay*drcq2+coe*d5q2$
(C113)  cp[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C114)  a133:q3*d1q3+ev1$
(C115)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C116)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C117)  cp[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C118)  a134:q3*d1q4$
(C119)  a434:ev4ay*drcq4+coe1*d4q4$
(C120)  a534:-ev5ay*drcq4+coe*d5q4$
(C121)  cp[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C122)  a135:q3*d1q5$
(C123)  a435:ev4ay*drcq5+coe1*d4q5$
(C124)  a535:-ev5ay*drcq5+coe*d5q5$
(C125)  cp[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C126)  rcazt:rc*azt$
(C127)  ev4az:ev4*azt$
(C128)  ev5az:ev5*azt$
(C129)  coe1:q4+rcazt$
(C130)  coe:q4-rcazt$
(C131)  a141:q4*d1q1$
(C132)  a441:ev4az*drcq1+coe1*d4q1$
(C133)  a541:-ev5az*drcq1+coe*d5q1$
(C134)  cp[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C135)  a142:q4*d1q2$
(C136)  a442:ev4az*drcq2+coe1*d4q2$
(C137)  a542:-ev5az*drcq2+coe*d5q2$
(C138)  cp[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C139)  a143:q4*d1q3$
(C140)  a443:ev4az*drcq3+coe1*d4q3$
(C141)  a543:-ev5az*drcq3+coe*d5q3$
(C142)  cp[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C143)  a144:q4*d1q4+ev1$
(C144)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C145)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C146)  cp[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C147)  a145:q4*d1q5$
(C148)  a445:ev4az*drcq5+coe1*d4q5$
(C149)  a545:-ev5az*drcq5+coe*d5q5$
(C150)  cp[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C151)  rctt:rc*tt$
```

```
(C152)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C153)  rt:rc*dttq1+tt*drcq1$
(C154)  a151:2*coe*d1q1$
(C155)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C156)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C157)  cp[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C158)  rt:rc*dttq2+tt*drcq2$
(C159)  a152:coe*d1q2-d1q1*q2$
(C160)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C161)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C162)  cp[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C163)  rt:rc*dttq3+tt*drcq3$
(C164)  a153:coe*d1q3-d1q1*q3$
(C165)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C166)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C167)  cp[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C168)  rt:rc*dttq4+tt*drcq4$
(C169)  a154:coe*d1q4-d1q1*q4$
(C170)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C171)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C172)  cp[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C173)  rt:tt*drcq5$
(C174)  a155:coe*d1q5$
(C175)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C176)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C177)  cp[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C178)  q1:q1$
(C179)  q2:q2$
(C180)  q3:q3$
(C181)  q4:-q4$
(C182)  q5:q5$
(C183)  ztx:-ztx$
(C184)  zty:-zty$
(C185)  sign:-1$
(C186)  cgg1:(gam-1)/gam$
(C187)  cgg2:1/(2*gam)$
(C188)  sada:sqrt(ztx**2+zty**2+ztz**2)$
(C189)  axt:ztx/sada$
(C190)  ayt:zty/sada$
(C191)  azt:ztz/sada$
(C192)  rqrq:q2**2+q3**2+q4**2$
(C193)  q6:1/q1$
(C194)  pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195)  prgam:pr*gam$
(C196)  pp:q5+pr$
(C197)  c:sqrt(prgam*q6)$
(C198)  tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199)  rc:q1*c$
(C200)  csad:c*sada$
(C201)  e1:tt*sada$
(C202)  e4:e1+csad$
```

```
(C203)  e5:e1-csad$
(C204)  ev1:e1$
(C205)  ev4:0.0$
(C206)  ev5:e5$
(C207)  cg1:cgg1$
(C208)  cg2:0.0$
(C209)  cg3:cgg2$
(C210)  d1q1:-ev1*q6$
(C211)  d1q2:ztx*q6$
(C212)  d1q3:zty*q6$
(C213)  d1q4:ztz*q6$
(C214)  d1q5:0.0$
(C215)  coe:gam*(gam-1)/(2*rc)$
(C216)  gm1q6:(gam-1)*q6$
(C217)  drcq1:coe*q5$
(C218)  drcq2:-coe*q2$
(C219)  drcq3:-coe*q3$
(C220)  drcq4:-coe*q4$
(C221)  drcq5:coe*q1$
(C222)  dcq1:(drcq1-c)*q6$
(C223)  dcq2:drcq2*q6$
(C224)  dcq3:drcq3*q6$
(C225)  dcq4:drcq4*q6$
(C226)  dcq5:drcq5*q6$
(C227)  depq1:0.5*gm1q6*rqrq*q6$
(C228)  depq2:-q2*gm1q6$
(C229)  depq3:-q3*gm1q6$
(C230)  depq4:-q4*gm1q6$
(C231)  depq5:gam$
(C232)  dttq1:-tt*q6$
(C233)  dttq2:axt*q6$
(C234)  dttq3:ayt*q6$
(C235)  dttq4:azt*q6$
(C236)  dttq5:0.0$
(C237)  d4q1:sada*(dttq1+dcq1)$
(C238)  d4q2:sada*(dttq2+dcq2)$
(C239)  d4q3:sada*(dttq3+dcq3)$
(C240)  d4q4:sada*(dttq4+dcq4)$
(C241)  d4q5:sada*dcq5$
(C242)  d5q1:sada*(dttq1-dcq1)$
(C243)  d5q2:sada*(dttq2-dcq2)$
(C244)  d5q3:sada*(dttq3-dcq3)$
(C245)  d5q4:sada*(dttq4-dcq4)$
(C246)  d5q5:-d4q5$
(C247)  a411:ev4+q1*d4q1$
(C248)  a511:ev5+q1*d5q1$
(C249)  cm[1,1]:cg2*a411+cg3*a511$
(C250)  cm[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C251)  cm[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C252)  cm[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C253)  cm[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
```

```
(C254)  rcaxt:rc*axt$
(C255)  ev4ax:ev4*axt$
(C256)  ev5ax:ev5*axt$
(C257)  coe1:q2+rcaxt$
(C258)  coe:q2-rcaxt$
(C259)  a121:q2*d1q1$
(C260)  a421:ev4ax*drcq1+coe1*d4q1$
(C261)  a521:-ev5ax*drcq1+coe*d5q1$
(C262)  cm[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C263)  a122:q2*d1q2+ev1$
(C264)  a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C265)  a522:ev5-ev5ax*drcq2+coe*d5q2$
(C266)  cm[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C267)  a123:q2*d1q3$
(C268)  a423:ev4ax*drcq3+coe1*d4q3$
(C269)  a523:-ev5ax*drcq3+coe*d5q3$
(C270)  cm[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C271)  a124:q2*d1q4$
(C272)  a424:ev4ax*drcq4+coe1*d4q4$
(C273)  a524:-ev5ax*drcq4+coe*d5q4$
(C274)  cm[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C275)  a125:q2*d1q5$
(C276)  a425:ev4ax*drcq5+coe1*d4q5$
(C277)  a525:-ev5ax*drcq5+coe*d5q5$
(C278)  cm[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C279)  rcayt:rc*ayt$
(C280)  ev4ay:ev4*ayt$
(C281)  ev5ay:ev5*ayt$
(C282)  coe1:q3+rcayt$
(C283)  coe:q3-rcayt$
(C284)  a131:q3*d1q1$
(C285)  a431:ev4ay*drcq1+coe1*d4q1$
(C286)  a531:-ev5ay*drcq1+coe*d5q1$
(C287)  cm[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C288)  a132:q3*d1q2$
(C289)  a432:ev4ay*drcq2+coe1*d4q2$
(C290)  a532:-ev5ay*drcq2+coe*d5q2$
(C291)  cm[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C292)  a133:q3*d1q3+ev1$
(C293)  a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C294)  a533:ev5-ev5ay*drcq3+coe*d5q3$
(C295)  cm[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C296)  a134:q3*d1q4$
(C297)  a434:ev4ay*drcq4+coe1*d4q4$
(C298)  a534:-ev5ay*drcq4+coe*d5q4$
(C299)  cm[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C300)  a135:q3*d1q5$
(C301)  a435:ev4ay*drcq5+coe1*d4q5$
(C302)  a535:-ev5ay*drcq5+coe*d5q5$
(C303)  cm[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C304)  rcazt:rc*azt$
```

```
(C305)  ev4az:ev4*azt$
(C306)  ev5az:ev5*azt$
(C307)  coe1:q4+rcazt$
(C308)  coe:q4-rcazt$
(C309)  a141:q4*d1q1$
(C310)  a441:ev4az*drcq1+coe1*d4q1$
(C311)  a541:-ev5az*drcq1+coe*d5q1$
(C312)  cm[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C313)  a142:q4*d1q2$
(C314)  a442:ev4az*drcq2+coe1*d4q2$
(C315)  a542:-ev5az*drcq2+coe*d5q2$
(C316)  cm[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C317)  a143:q4*d1q3$
(C318)  a443:ev4az*drcq3+coe1*d4q3$
(C319)  a543:-ev5az*drcq3+coe*d5q3$
(C320)  cm[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C321)  a144:q4*d1q4+ev1$
(C322)  a444:ev4+ev4az*drcq4+coe1*d4q4$
(C323)  a544:ev5-ev5az*drcq4+coe*d5q4$
(C324)  cm[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C325)  a145:q4*d1q5$
(C326)  a445:ev4az*drcq5+coe1*d4q5$
(C327)  a545:-ev5az*drcq5+coe*d5q5$
(C328)  cm[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C329)  rctt:rc*tt$
(C330)  coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C331)  rt:rc*dttq1+tt*drcq1$
(C332)  a151:2*coe*d1q1$
(C333)  a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C334)  a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C335)  cm[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C336)  rt:rc*dttq2+tt*drcq2$
(C337)  a152:coe*d1q2-d1q1*q2$
(C338)  a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C339)  a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C340)  cm[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C341)  rt:rc*dttq3+tt*drcq3$
(C342)  a153:coe*d1q3-d1q1*q3$
(C343)  a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C344)  a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C345)  cm[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C346)  rt:rc*dttq4+tt*drcq4$
(C347)  a154:coe*d1q4-d1q1*q4$
(C348)  a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C349)  a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C350)  cm[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C351)  rt:tt*drcq5$
(C352)  a155:coe*d1q5$
(C353)  a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C354)  a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C355)  cm[5,5]:cg1*a155+cg2*a455+cg3*a555$
```

```
(C356) diff:cp.m+m.cm$
(C357) diff:ratexpand(diff);
```

$$
\begin{bmatrix}
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0
\end{bmatrix}
$$

(D357)

```
(C358) closefile(Ccsub1)$
```